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NATIONAL
ELECTRIC LIGHT
ASSOCIATION.

Nineteenth Convention,
New York, N. Y.,
May 5, 6, 7, '96.

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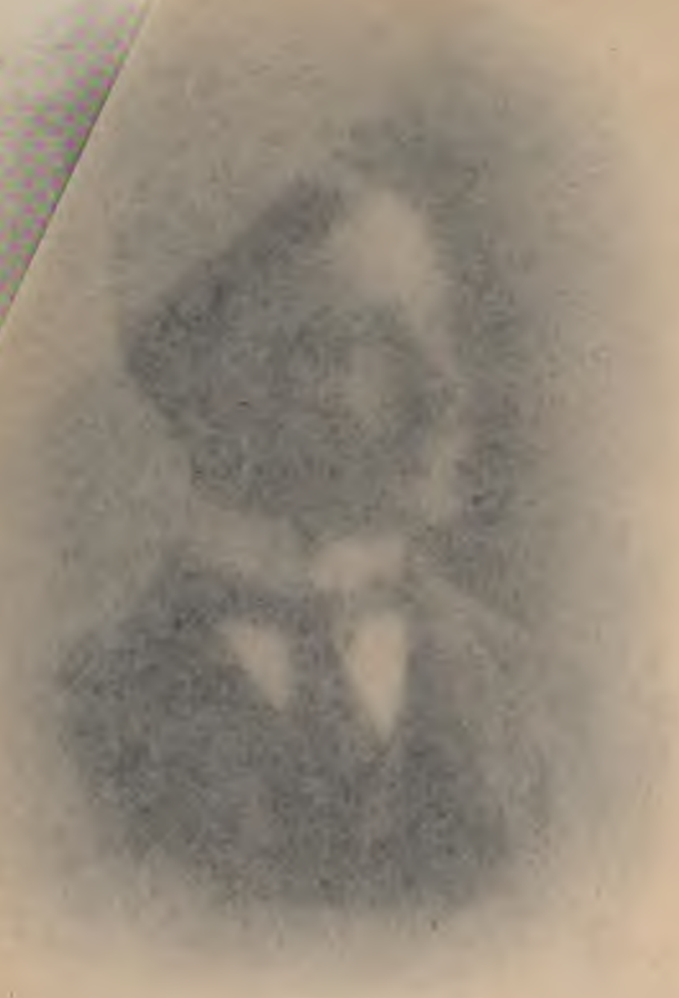

NATIONAL
Electric Light
ASSOCIATION.

NINETEENTH CONVENTION.

NEW YORK, N. Y.,
May 5th, 6th and 7th, 1896.

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CONVENTIONS OF THE ASSOCIATION

First	Chicago, February 25, 26, 1885
Second	New York, August 18, 19, 20, 1885
Third	Baltimore, February 10, 11, 12, 1886
Fourth	Detroit, August 31, September 1, 2, 1886
Fifth	Philadelphia, February 15, 16, 17, 1887
Sixth	Boston, August 9, 10, 11, 1887
Seventh	Pittsburg, February 21, 22, 23, 1888
Eighth	New York, August 29, 30, 31, 1888
Ninth	Chicago, February 19, 20, 21, 1889
Tenth	Niagara Falls, August 6, 7, 8, 1889
Eleventh	Kansas City, February 11, 12, 13, 14, 1890
Twelfth	Cape May, August 19, 20, 21, 1890
Thirteenth	Providence, February 17, 18, 19, 1891
Fourteenth	Montreal, September 7, 8, 9, 10, 1891
Fifteenth	Buffalo, February 23, 24, 25, 1892
Sixteenth	St. Louis, February 28, March 1, 2, 1893
Seventeenth	Washington, February 27, 28, March, 1, 2, 1894
Eighteenth	Cleveland, February 19, 20, 21, 1895
Nineteenth	New York, May 5, 6, 7, 1896

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Springfield, O., Springfield Light and Power Company
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A. J. De Camp
A. M. Young

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*Elected in place of E. F. Peck, promoted.

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ORDER OF BUSINESS

TUESDAY, May 5th, 1896

FIRST SESSION, 11 A. M.

1. Opening of Convention
2. President's Address
3. REPORT. Committee on Relations Between Manufacturing and Central Station Companies. A. J. DE CAMP, Chairman

SECOND SESSION, 3 P. M.

1. Announcements
2. Paper—"The Commercial Value of Acetylene Gas as an Illuminant." By LOUIS A. FERGUSON
3. Paper—"Single-Phase Self-Starting Synchronous Motors." By F. A. LEONARD, JR.
4. Paper—"Equalizer Systems of Distribution." By A. CHURCHWARD

MINUTES

OPENING OF THE CONVENTION

The association met in the Industrial Building, Tuesday, May 5th, 1896, and was called to order at 11 a. m. by the president, C. H. Wilmerding, who said :

Members of the National Electric Light Association :

It has usually been customary, when we have met, to be welcomed by some city official. On this occasion, His Honor, Mayor Strong, is not able to be present, and we must welcome ourselves. The meeting will be opened with the president's address.

PRESIDENT WILMERDING'S ADDRESS

Members of the National Electric Light Association, Ladies and Gentlemen : The National Electric Light Association owes its birth to a meeting of those interested in the problems of electric central station lighting, held a little over eleven years ago, on the 25th of February, 1885, at the Grand Pacific Hotel, in Chicago. Many of those who came together at that time are here to-day—a little older, it is true, and a great deal wiser in matters pertaining to the subjects they met to discuss ; in fact, if we turn to the records of that first meeting, we can but be struck by what, in the light of our present knowledge, appears to be the lamentable ignorance of those same gentlemen; and yet it must be remembered in their favor, and in extenuation, that they knew as much as could have been expected of them in those earlier days of electrical development. They meet to-day in their nineteenth convention, and those of you who will follow the proceedings will see that they have improved—it is only fair to give them this opportunity to vindicate themselves—and I think I may add that you will find at the end that the improvement has not been entirely one-sided.

In these few years the central station for the production and dissemination of electric current for lighting and power has practically been developed: It barely existed in those days. It is needless to say that it enjoys a very vigorous and healthy life at the present time. It is, I think, without undue self-congratulation that we can say that the association has contributed its share to this progress, and we therefore owe a debt of gratitude to those who met in Chicago; for even if they did know very little about electricity, they foresaw the wisdom of co-operation and the value of the free exchange of thought and ideas, which have made the association what it is to-day.

The object of any such organization as this is primarily the advancement through mutual intercourse of its individual members, and secondarily the fostering and protection of their common interests. In both of these fields we can say with some pride that this association has, since its inception, steadily advanced, and with each year of its growth we have seen that it exerted a greater influence, that it afforded a greater opportunity for the acquirement of technical and practical knowledge, and that, in proportion as it has become a stronger and more homogeneous body, it has grown to be a greater necessity to central station interests. In this twelfth year of its existence we hope it may keep up with the steady improvement of former years, and advance as nearly as possible in lock-step with the progress of electricity itself.

When our fellow countryman, Benjamin Franklin, flew his silken kite, an event which marks the first step toward present achievements, he drew from the clouds a tiny spark. That spark was then but like the twinkle of a star, billions of miles away. It hinted at the existence of an unexplored world, but so faintly that the most powerful telescopes of imagination failed to measure its dimensions or to determine its course. Gradually new facts were added, one by one, concerning this mysterious, distant star; it grew brighter; it was certainly coming nearer and nearer within the reach of man, but it was only a few years ago that it assumed the proportions of a body of the first magnitude, and so rapid has since been its onward progress that to-day that tiny spark has grown to a brilliant midnight sun, dispelling darkness throughout the civilized world. Such has been the meteoric course of the science that brings us here now. What in the days of our childhood was scarcely more than a toy—at best the interesting and mysterious phenomenon of the scientist's laboratory—is in these closing years of the century the mightiest agent known to man. By its means the news of the world is gathered from its four corners in less than a second's time; yesterday it carried the command by which Governor Morton called the wheels of our exposition into life over 6,000 miles, from the Atlantic to the Pacific and again to the Atlantic, at a touch of the finger and in less than the twinkling of an eye. Through its agency the softest whisper of the human voice is transmitted a thousand leagues, or recorded and preserved for the ears of future generations; the divisions of time are so integrated as to enable the eye to follow in reproduction the continuity of the most rapid motion; night is turned into day, darkness into light; the waste forces of nature are harnessed and wafted like spirits, unseen and instantaneously, over mountains and rivers, miles upon miles, to turn the busy wheels of distant industry; the hidden secrets of nature are laid bare by the ray that pierces dense matter with the ease of a shaft of sunlight traveling through thin air. One miracle has followed another, until we can but wonder what apparent impossibility will be accomplished next. The fables and fairy tales of old pale before the facts of the present day.

Nothing could show more succinctly the various steps of this advance than the historical exhibit forming a part of the exhibition opened in connection with this convention, which we owe to the efforts of Mr. T. C. Martin, Mr. Morse and Mr. Park Benjamin. The literature of the science is shown from its earliest infancy; the crude original designs are there of apparatus that has since attained perfection; the gradual growth of many great ideas is fully illustrated from their inception, and it is only necessary to turn to the other and present-day departments to see them in their completed forms, and to realize the recent extraordinary achievements of electrical inventors. Supplementing this, is the prolific exhibit from the Patent Office, an inspection of which can leave no further doubt as to the activity that has been going on in this field of science.

The last exhibition of this nature was the great display at the World's Fair at Chicago, in 1893. Only three years have elapsed since then, and yet it can be plainly seen that in the meanwhile a sort of Darwinian evolution has been going on, developing things then unheard of and unknown, though the natural progeny of earlier germs, now fructified by the power and genius of the great minds that have fathered them.

The most recent of these triumphs of science, and the one that has attracted the most widespread interest and perhaps promises the greatest results in a scientific way, is the marvelous discovery of Prof. Röntgen—the cathode or X ray. Thanks to the courtesy of Mr. Thomas A. Edison, the application of this strange light, the methods employed to obtain sciagraphs, and the use of his newly invented fluoroscope—by which one can see, as through a stereopticon, the bones of one's own anatomy—are graphically shown and explained by the assistants from his laboratory.

Equally new to the world, and first brought forward by another of our distinguished honorary members, Mr. Nikola Tesla, are the beautiful and curious effects in lighting produced by high-frequency, high-voltage currents, which will be shown by Mr. McFarlan Moore as he has developed them and applied them to practical use. Mr. Moore, perhaps in a true spirit of prophecy, describes this as the "Light of the Future."

Still another invention, which has seen the light of day since the Columbian Fair, and also owes its origin to the fertile brain of Mr. Tesla, is the oscillator, by means of which unique contrivance much of the machinery now required for generating electricity is dispensed with, and current is derived directly from the energy of steam.

Although the mere transmission of current over long distances is not absolutely new in the sense that the expression must be taken in speaking of things electrical—for it dates back three or four years—yet all the features of the great example of such transmission shown here are individually novel, and the exhibit as a whole may be classified as one of the most significant of all. The generators producing the current at Niagara, as well as the turbines that actuate them, are the largest that have yet been built and successfully operated; and the two-phase winding of the former represents the latest advance in the construction of dynamos for the distribution of power. The line carrying the energy to this city traverses a distance of 462 miles, which is 347 miles longer than the celebrated Frankfort transmission, the longest hitherto attempted. The successful accomplishment of this feat is an indication of great future possibilities in the utilization of natural advantages for the supply of power over wide areas, and, at the same time, adds a further argument in favor of the rapidly growing tendency toward unification and centralization of generating plants.

A reference to these more strictly scientific advances in electricity leads to the consideration of its growth commercially. Figures are certainly the most convincing expression of the measure of achievement in this direction, and the following facts will carry with them their own conclusions.

About seventeen years ago the first central station was established; at present there are 2,500 electric light companies in the United States and about 200 municipal plants. These central stations represent an invested capital of over three hundred millions. There are, in addition, about 7,500 isolated plants, which have required the expenditure of two hundred millions more. An idea of the capacity of these 10,000 installations may be formed when it is known that there are produced daily for their use from 50,000 to 75,000 incandescent lamps; that the annual consumption of carbons in arc lamps is 200,000,000, and that 500,000 stationary electric motors are operated by the current that they generate.

The electric railway is of still more recent birth, dating back but ten years; and yet, at the present time there are no less than 900 such roads in this country, using 11,000 miles of track, operating 25,000 cars and involving an investment of about seven hundred and fifty millions of dollars; and this investment is increasing annually at the rate of one hundred millions for new roads and new equipment. While these are large figures, they do not at all represent the total capital employed in electrical industries. The manufacturers of the apparatus and supplies used to carry on this enormous business, and the dealers who handle them, probably have at stake a sum sufficient to build and equip all the central station plants in the country; and if the auxiliary enterprises, such as those of the producers of copper, the makers of boilers, the engine and car builders, fixture manufacturers, glass workers, and a score of others who depend in a large degree and, in some cases, exclusively upon the electrical trade, are considered, the grand total will reach a sum that any country might be proud of as a national debt.

This astounding growth affords a striking example of American enterprise as compared with that of the Old World. Against 900 electric railways in this country, there are less than one hundred in all Europe; and as to electric lighting, the output of a single company in New York, or of a single company in Chicago, is greater than the combined output of all the stations in the brilliant city of Paris.

The short period since our last meeting has in itself marked an epoch of the greatest importance in electrical engineering. The Niagara Falls power plant has been completed and put into successful operation. The first elevated electric railway, the Metropolitan, of Chicago, has been opened for public travel, and has already demonstrated that such a road can be operated at about one-half the cost of a steam road, and making it merely a question of time, and a short one at that, before all elevated trains must be propelled by the same cleanly and economical means.

The first powerful electric locomotives of the Baltimore and Ohio Railroad have been put into regular service in the Baltimore tunnel, drawing the heaviest trains, and furnishing an example which other railway companies are preparing to follow. This is undoubtedly the first step toward a general revolution in the methods of transportation, which will result not only in greater comfort and better service to the public, but in such a saving to the companies themselves as will place many a road, now on the verge of bankruptcy, on a prosperous and dividend-paying basis.

I am glad to be able to say that, while everything else electrical has been forging ahead, the National Electric Light Association has not been standing still. The reports that will be submitted by the Committee on Rules for Safe Wiring and the Committee on Data will show that they have accomplished much valuable work during the past year. The progress that has been made by the former committee toward bringing about the general adoption of a national code of rules for electrical installation is especially gratifying, and we may at last hope that this much-to-be-desired and long-deferred result of their labors will soon be attained. We have all suffered from the lack of fixed standards governing electrical construction and from the arbitrary rulings of self constituted authorities on this very important subject; and the establishment of a board composed of competent and representative men, whose rules will be consistent and, as far as possible, permanent, is one of the greatest of our needs, the realization of which should be one of the first aims of the association.

The report of the Finance Committee will also be found interesting and extremely satisfactory; showing as it does, that our treasury is in a better condition than ever before.

We have been particularly fortunate in securing papers to be read before this convention upon subjects which are timely and of special interest to central station men; and I desire to take this opportunity to thank the gentlemen who have prepared them and who will read them, for their willing co-operation with the officers of the association in their efforts to make this meeting a successful and an instructive one.

I trust, gentlemen of the association, that you will all co-operate toward this result, at least to the extent of a regular attendance at our sessions; resisting while the convention lasts, if not longer, all the subtle temptations and seductive allurements of this fair City of Greater New York.

THE PRESIDENT: Gentlemen of the Association, I now declare the Nineteenth Convention of the National Electric Light Association to be opened and ready for the transaction of business.

Is the Committee on Standard Rules for Electrical Construction and Operation ready to report?

MR. HAMMER: I should like to say, Mr. President, that I was unable until yesterday afternoon to discover on what part of the programme our committee report was to come, and our committee desire to have a final conference before presenting it. It is an important report, and I believe that by to-morrow afternoon we shall have it ready for presentation.

THE PRESIDENT: We will now proceed to the report of the Committee on Relations between Manufacturing and Central Station Companies. Is that committee ready to report?

REPORT OF COMMITTEE ON RELATIONS BETWEEN MANUFACTURING AND CENTRAL STATION COMPANIES

MR. DE CAMP: Mr. President, that committee is now of such long standing, and the matter is in such shape, that I think the committee can very well be dispensed with. As a matter of fact, nothing has ever come before the committee that could be so shaped that the committee could act at all. There is practically no report to make, and I would move that the committee be discharged.

THE PRESIDENT: It is moved and seconded that the Committee on Relations between Manufacturing and Central Station Companies be discharged.

MR. ARMSTRONG: I should like to inquire if this is not the first time the committee ever made a report?

THE PRESIDENT: So far as my recollection goes, it has never reported.

MR. DE CAMP: The committee has never made a report, and I think it should be discharged.

THE PRESIDENT: I think Mr. De Camp's suggestion is a good one; I do not see any use in continuing the committee.

MR. BEGGS: Mr. President, I believe I have the honor, if such it may be called, of belonging to a committee that has never been called together; and how it is possible for the chairman of a committee to formulate a report and present it here, saying there was nothing for it to do, when the committee has never met in order to determine whether there was anything that might be accomplished between this association and the manufacturing or parent companies, is very strange to me. I certainly must, as an active, practical central station man, both from the managing and investing standpoint, disagree with the statement just made by the chairman of the committee, beside whom I have been sitting without knowing who he was. I believe there is a great deal, Mr. President, for some committee—or for this association if it does not act through a committee—to do for the central station companies in this country in their relations with the manufacturing and parent companies. If there is not, what are we here for? I should like to know what the mission of the National Electric Light Association is. What do we hope to accomplish by keeping it in existence? I consider that the most important matter that can come before this association is the subject of the relations between ourselves and those from whom we are compelled—if we are to continue doing as we have done in the past—to obtain the apparatus with which we run our stations, and compete with apparatus that they are trying to put into the hands of others who are doing everything in their power to wreck the business of the central station men assembled here to-day.

I think that if Mr. De Camp had been present at the last annual meeting of the association, at Cleveland, he would possibly have seen that there were reasons why this committee should at least have been convened during the past vear to determine whether or not there was not a great deal to be accomplished between the representatives of central stations and those to whom we have paid millions of dollars for apparatus, and likewise for bonuses. I therefore disapprove his suggestion to discharge the committee because there is nothing for it to do. It may be perfectly right to discharge the present committee; but that we should abolish all committees of this kind is not acceptable to me, and I take issue on that point. I think there is a great deal for an active, intelligent and reasonably aggressive committee to do on the very lines of action for which this committee was appointed. It has been admitted here by the chairman, that the committee has never met, and has never made a report. I think that is the best evidence that it has never attempted to do anything. There are a few things that, as a member of this association, I should like to know. I know it was intimated a year ago that the good taste of my speaking upon the floor might be challenged, for the reason that I had taken so little active interest and had met so infrequently with your association. One reason, gentlemen, for that is that many of the most active and most largely interested central station people of this country have found it difficult, if not impossible, to see that anything of material value has been accomplished for them by this association. As a central station man, actively engaged in central station work for twelve years, I have looked earnestly to find something of great value that has been accomplished by this organization, but have been unable to find it. There are other organizations that do accomplish a great deal. I think that the one thing in which there is more room for this association to exercise its influence on behalf of central station companies is just in this line of the relations between the central stations and the manufacturers; and, gentlemen, a fact of very recent occurrence would seem to indicate that the central station people of this country need to get closer together because of the example set by the close union that is being brought about between the larger manufacturers and patent owners of electrical apparatus of this country, who are to a very great extent dependent upon the central stations for their business, and who are spending millions of dollars annually in the purchase of new apparatus and supplies.

For these reasons, I disapprove of the idea that this committee should be dispensed with. I, as a member of the committee, am sorry that it has not been deemed of sufficient importance to convene during the past year or fifteen months since we met at Cleveland, in February, a year ago. Mr. De Camp may speak for himself, but not for the entire committee.

MR. ARMSTRONG: Our friend Mr. Beggs was, I think, out of order from a parliamentary standpoint.

MR. BEGGS: Often so, in the opinion of those with whom I take issue.

MR. ARMSTRONG: I never heard of a proposition that a committee was to be called together. A committee is formed so that the chairman can have additional dignity; that is all. The idea of supposing that the committee is to be called together! It is ridiculous. Have not we heard the chairman of the other committee here say that he was busy and has not had time to make his report? He said, parenthetically, that he desired to get his committee together before making the final report; he put that for an excuse. The chairman has got to have the members for an excuse; that is what they are for. Suppose I am not ready with my report? I lay it to the fact that the committee has not met. If I have my report ready, it does not matter whether the committee has met or not. It never does. I never understood that the committee consisted of more than the chairman, except for the incidental purposes spoken of, and I was surprised to hear my friend Beggs make such an insinuation.

I like to take issue with him, because he is a fighter. He is an Irishman in everything but blood and birth. He believes in hitting out from the shoulder. The first time I met him was in a convention where he was letting out his right hand and left hand.

I have had some experience with the manufacturing companies that are oppressive to us, but the president of the large and magnificent one, the *general* one, said to me: "Oh, no! you are mistaken; of course, we have close relations with some of the companies that have been trespassing upon you somewhat, but then, they are only small affairs. While this has happened, we are sorry for you, and we will see whether it cannot be adjusted." That was two years ago; possibly it has been adjusted, but the committee has not been got together. I do not know whether the chairman is ready to report or not. I have not heard of any such adjustment. I believe, and firmly believe, that it would be possible to bring about—not in the way Brother Beggs prefers to do it, but in other ways—better relations if the thing were gone at in the right manner. I supposed everybody had some suggestion whereby things could be remedied. I do not know if I am speaking by the book when I say that during the past year our common enemy have had sufficient troubles of their own not to trouble us so much as they have done in the past, and, possibly, we have been getting along more smoothly. I speak only from my own experience; I do not know how it is with others.

I want to take issue with Brother Beggs as to the lack of things accomplished by this association. He has not attended the meetings as faithfully as some of us here. Possibly we had more to learn; possibly we came in the kindergarten style, and have only now got up in the primary rooms of this great common school; but some of us have profited by rubbing up against those gentlemen who are practical, those who are scientific, and those who are looking at the return for dollars; and we have learned a great deal. I would not miss an attendance at one of these meetings for anything that I know of. It is not so much because of the printed programmes, for I have learned after some years of attendance at conventions not to depend much upon the titles on the programmes. I have learned to depend more upon what is said incidentally; more upon what is learned very often outside of the sessions of the convention than what is learned in the convention.

While I am heartily in favor of what Mr. Beggs says in relation to keeping up this line of work, I am not so sure but that the motion of Mr. De Camp is in order. We have had the committee standing for a long time under this title. Sometimes familiarity breeds contempt.

Sometimes when we become too much accustomed to a certain line it is well to change it; and, therefore, I shall vote heartily for this motion that the committee be abolished, the name be abolished, and I shall vote just as heartily for Mr. Beggs's motion that something else be substituted to do the work that this committee was intended to do.

Mr. Francisco: This committe has been standing on our list for years. At the Cleveland convention, I called the attention of the members to the fact that there had never been anything done by this committee. I appointed Mr. Beggs chairman of the committee at Cleveland, with the express understanding that there was to be some work performed. Mr. Beggs excused himself from acting as chairman, and Mr. De Camp was substituted. Mr. De Camp, not being present at the Cleveland convention, had no choice in the matter, and did not know that he had been made chairman until after the convention adjourned. It was plainly understood and agreed at the time of the appointment of the committee that active work would be performed during the year, so that the committee could make a report at this convention. Mr. Beggs says there has been no meeting whatever of the committee; therefore, I say, discharge the committee, and drop the matter, unless you can get somebody on the committee who will perform active work. This idea of putting up a figurehead and passing it along from year to year, is nonsense. In regard to this committee having any matters to deal with, I think I have a chance to speak from personal experience as well as any member of the convention. I have these very things in my own business, and have had for years. I know what this plan of letting these matters float along amounts to, and I am in favor of discharging the committee unless some effective action can be taken.

Mr De Camp: In answer to the points made by Mr. Beggs, I do not know what may have been done at the Cleveland convention, but I do know what was the general sentiment when the committee was first formed. It was this: There were these perplexities arising between the manufacturing companies and the central stations. The central station men, individually, did not seem to be able to cope with the manufacturer, who, for the time being, was his enemy by making encroachments upon his business. Hence the formation of this committee, whose duties were to confer with the manufacturing companies in such manner as might seem to them to be most effective, with a view to reconciling the difference between some particular company and the manufacturing company. To bring about that result, it was supposed that any member of this association having a grievance would make that grievance known to the committee, when it would become the duty of the committee to take it up and make an appeal to the manufacturing company on behalf of the central station, as being a representative committee of this association. Now, the duties of this committee were nothing more than that; and since I have been a member of it (while I have not been chairman of it always, I have been a member ever since it was appointed), so far as my knowledge goes, the committee has never had a single communication from any aggrieved member of this association. Therefore, they had nothing to act upon. Anyone who is connected with this association, as an officer or as a member of a committee, knows that there is more or less to do in connection with such work, and we also all have duties outside of this association. Now, in the first place, the excuse that I have to offer for this committee not having been called together, is that no one suggested a subject for them to deal with that required them to be called together. As to calling them together as mere matter of formality, I take it that it is not a part of the duty of a member of any committee to take his time away from his legitimate business, and the time of others from their business, to discuss something that does not exist. I repeat that, since the formation of this committee, I have never heard of anyone asking the committee to take any action. That would seem to be an evidence that the members of the association who have had such grievances have either been able to paddle their own canoes out of their difficulties, or they have not had any faith in the ability of the committee to accomplish anything. I think that, taking that view of the case, the best thing that you can do is to abolish this committee; whether or not you create another committee for a similar purpose is another question.

MR. HAMMER: I should not like the good-natured remarks of Judge Armstrong to go on record without a word about our committee. Personally, I do not think any committee should exist without doing work——

THE PRESIDENT: Mr. Hammer, you seem to be out of order.

MR. HAMMER: I refer to the presentation of our report. I should like to make an explanation if there is no objection.

THE PRESIDENT: If there is no objection, Mr. Hammer can speak.

MR. HAMMER: This committee of ours is a working committee. We have had 500 or 600 letters from interested gentlemen in different parts of the country. We have worked a long time, and, as our president in his address referred to the conclusion of our committee's work, I think you will agree that the importance of it, and the desire of presenting the report fully and thoroughly before you and not having it brought before you in a superficial way, was the reason why it was deferred until to-morrow afternoon. I feel, as chairman of the committee, and in justice to the other members of the committee who have done very hard work, that it is desirable to make this statement.

MR. ARMSTRONG: There must be an exception to prove every rule.

MR. SEELY: Do I understand Mr. Hammer to state that his committee will report in full to-morrow afternoon?

THE PRESIDENT: So I understand.

MR. SEELY: We shall be delighted to hear from that committee in full.

MR. BEGGS: A word of explanation is due, in view of the remarks made by Mr. Armstrong and also by Mr. De Camp. Mr. De Camp has given an entirely different coloring as to what was to be performed by the committee. I think the discussion had at Cleveland fifteen months ago outlined to be performed by the committee very different duties from those that Mr. De Camp understands to have been its duties. They were not specific at all. Gentlemen who were present at Cleveland must certainly recollect that this matter was discussed at two or three different sessions of that convention, and it was presumed—and it is not by any means an idle presumption—that there was a *general grievance* that applied to all central station companies, that should be taken up by an active, forceful, intelligently aggressive committee to rectify, not an individual grievance, such as that to which Judge Armstrong has referred in the remarks that he has been pleased to make regarding a certain other organization into which he came especially to obtain relief for a personal grievance. I may say to him that if he had attended the next annual meeting of that association he would have heard the report of a committee that showed that it met repeatedly, and that within thirty days after the meeting at which the committee was appointed, it met general officers of the organization against which Judge Armstrong had his grievance, and obtained very effective results, which, whether Judge Armstrong knows it or not, his company has had the benefit of from that day, now nearly two years ago, to this. That committee is an active, effective one.

You may, gentlemen, get something by these mild measures from the organizations with which you are dealing, and too often indirectly competing, but my experience has been to the contrary. Their words are very sweet and flowery, their promises are indeed magnificent in their proportions; just as magnificent in their proportions as their performances are insignificant. Therefore, I say that there is a great deal to do; not, however, as Mr. De Camp has stated, simply to take up some personal grievance that may be referred to the committee by some individual company; that is not my idea of what a committee of this kind should do; it should take up the broad question—the broad question of the honesty and fairness of these manufacturing and parent companies going into territory already fully covered by central station service, simply for the purpose of exploiting the sale of additional and unnecessary apparatus and of wrecking capital. I am here to say that if this organization of central station men from all parts of the country would take hold of this vital question actively and aggressively, Mr. Francisco would not be compelled to sell arc lights at $2.33 per month to burn until twelve o'clock every night in the year, simply because some decoy duck or blackmailing organization, owned, or indirectly owned, by these parent and manufacturing companies seeks to obtain franchises, and to which organization the manufacturing companies desire to sell a new outfit in that city. That is not an exceptional case, by any means. The results, probably, are more disastrous than in some other cases. I see sitting here a number of gentlemen who are laboring under similar conditions to-day. That is my idea of what a strong, aggressive committee should deal with—the general question between the central station people who compose this organization, our various state organizations now springing up, and the electrical manufacturers and pool owners of electrical patents. I tell you, gentlemen, that the central stations to-day represent possibly a hundredfold the amount of capital that is represented by the manufacturing and parent companies.

I will withdraw my opposition to the discharge of the committee, if it was formed for the purpose stated by Mr. De Camp, because I do not see any force in that; but I believe that a committee should be appointed, continued, and required to make a report to this organization; and that report to mean something. I certainly think that is a very great necessity.

MR. ARMSTRONG: I confess that I may be obtuse, but I cannot see the difference between "personal," if you so choose to call it, and "general," as defined by Mr. Beggs. I represent a company not a member of this organization, although its affiliated companies are members of this association, and, therefore, except by way of illustration, I had nothing to say as to that company's affairs; it was not proper to bring that company's affairs up here. I represent two companies that are members of this association, that have no special grievance against any manufacturing company, and therefore cannot make any charge, but I gave that as an illustration, and simply as an illustration, of my experience of the treatment of the manufacturing company toward a company to which it ought to devote its best efforts for good. My experience, when I personally went to the companies, was that I was patted on the back and requested to keep still and everything would come out all right. I did not know that I dropped in accidentally; I thought I went purposely into an organization that would help the company that had a right to come in there, as I understood it, and had a right to ask assistance; and I was not at all backward in asking assistance, and was gratified in hearing vigorous remarks from members of that association promising assistance. On that general line, I am told, incidentally, much good was accomplished for everybody, although, so far as I yet know, no good was accomplished, and it was practically said that it was not intended to be accomplished, for my personal company. While I am broad enough to desire to benefit the whole community, I am also narrow enough to desire the special benefit of my own company. That is why I come to these conventions, and, I apprehend, that is why all of the companies pay dues into this organization. And, while it is absolutely true that this was made with a specific purpose, assaults were made in Boston, assaults were made in

Rhode Island, assaults were attempted in Philadelphia, assaults were made throughout the Union by these companies that were desirous of selling apparatus, and that were organizing and fostering companies in opposition to us. It was not the general thing; it was because of specific onslaughts made upon invested dollars that we gave attention to this.

There is nothing that moves upon us with the same force as when we are touched as has been this gentleman who has been so long an honored member, and honored by being our president; and when other companies are affected as he was affected and is being affected, they will arouse to the necessity for some action.

I am not only willing, but anxious, that some committee shall be appointed to carry out all that Mr. Beggs desires, taking the most drastic measures, if need be, and let it be in the line, if you please, of Mr. De Camp's idea. He was right, as I recollect. It was with the idea that through this committee the association would go directly to the manufacturers and say: "Look here; we believe from the representations made to us that you are doing wrong; that you are injuring one of our members. We think you ought to do right." It was for that specific purpose that the committee was appointed.

It is very true that in February, 1895, a broader scope, a wider line of action, was suggested for this committee; and, after some such discussion as this, the committee was appointed with the idea that it would carry on its work in that broader way. It has since, either from history, tradition, or something else, found that it could not well be done, and, therefore, I said I should be happy indeed to vote for Mr. De Camp's motion to discharge the committee. I trust, however, that I shall be permitted to vote on a resolution by Mr. Beggs that will give us some other committee with this broader scope and higher powers, if you may call it so; certainly a higher object.

Mr. De Camp's motion to discharge the committee was then put and carried.

THE PRESIDENT: Has Mr. Beggs any motion to make?

MR. BEGGS: Not at present. I do not aspire to the honor of being chairman of the committee. I would, however, do all that lay in my power to aid any committee with which I might be associated, but I am slow to assume additional responsibilities, particularly as I have not been as constant an attendant at these meetings as some others. Therefore, I was willing to follow the lead of one who was older in the organization, and to lend such assistance as I might be able, and I am still willing to do so.

THE PRESIDENT: The afternoon session, which will take place at half past two, will be held in the large room on the fifth floor, adjoining the secretary's office.

At eight o'clock this evening, there will be a lecture by Mr. Max Osterberg on "The Röntgen Ray," which will be held on the sixth floor, in the hall that is reached by elevators to the right of the main entrance.

MR. NICHOLLS: Will the elevators be running?*

THE PRESIDENT: These are steam elevators, and you will probably get up there. It is rather hard in an electrical convention to make this reflection on electric elevators. I think it is a local trouble; we have not found it elsewhere.

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* The electric elevator that conveyed the delegates to the convention hall on Tuesday morning was not running satisfactorily.

If there is no objection, we will make the hour of convening three o'clock, and I hope everybody will be on hand, so that we can get through the programme.

The meeting then adjourned until three o'clock.

AFTERNOON SESSION

The convention was called to order by President Wilmerding at three o'clock.

ANNOUNCEMENTS

The following letters were read by the president:

"New York, April 28th, 1896.

"Mr. C. H. Wilmerding,
"President National Electric Light Association,
"136 Liberty Street, City.

"My Dear Sir: Your favor of April 24th has been received.

"I wish herewith to thank you for the courteous invitation extended to me, and to assure you that I earnestly hope the convention this year will be a great success.

"Very truly yours,

"N. Tesla."

"Boston, Mass., April 28th, 1896.

"C. H. Wilmerding, Esq.,
"President National Electric Light Association,
"136 Liberty Street, New York.

"My Dear Sir: I have this morning received your kind letter of April 24th, inviting me, as an honorary member, to attend the Nineteenth Convention of the National Electric Light Association.

"I expect that I shall have to be in Washington on business requiring personal attendance on the 5th and 6th of May, but I hope to be in New York on the 7th, and if I can do that, I shall give myself the very great pleasure of being present with you on the last day of the convention.

"Very sincerely yours,
"THOMAS D. LOCKWOOD."

"NEW YORK, April 10th, 1896.

"MR. GEORGE F. PORTER,
"Chairman of Committee,
"136 Liberty Street, New York.

"DEAR SIR: In the name of the President of the American Surety Company, I offer to the ladies and members of your association and invited guests, the privilege of the roof of this building, which is 310 feet above the level of the sidewalk, for the purpose of viewing the City of New York and the surrounding country, on Saturday, May 9th, next, from two to four o'clock in the afternoon.

"I would suggest that all visitors who come will wear the button or colors of the association.

"Yours respectfully,
"JOHN TURNER,
"Supt. and Engineer."

"NEW YORK, May 5th, 1896.

"C. H. WILMERDING, Esq.,
"President National Electric Light Association,
"New York City.

"DEAR MR. WILMERDING: The Edison Company will be glad to welcome the members of the National Electric Light Association at its Duane street offices and station on any evening which is not otherwise occupied by its programme, when arrangements will be made to show visitors about the station systematically. If that should not be practicable, arrangements will be made to show individual members about the more interesting parts of the building on presentation of their credentials of membership at the office of the General Operating Superintendent in the general offices on Duane street.

"It is to our regret that the new Twelfth street station is out of commission for the summer months, so that it cannot be effectively shown. The equipment of the operating room there, with the exception of the steam turbine, is only temporary, however, and we will arrange to let those members who desire, see the steam turbine installed at our station in Thirty-ninth street, near Sixth avenue. Our Assistant Superintendent, Mr. Edward Williams, in charge of the Thirty-ninth street station, will have instructions to admit members of the association, on showing their credentials, any afternoon between the hours of two and five. This turbine is also out of commission for the summer, and can therefore be seen only as a 'still exhibit;' but we may arrange, if desired, to run the turbine on a special afternoon, when it can be seen by members generally.

"With best wishes for the success of the present meeting, I am,

"Very truly yours,
"R. R. Bowker,
"First Vice-President."

"April 4th, 1896.

"Mr. Geo. F. Porter,
"Secretary National Electric Light Association,
"136 Liberty Street, City.

"Dear Sir: We wish to extend to the members of the National Electric Light Association, and friends, an invitation to visit our works at Ampere,

N. J., one evening during the convention. The trip will be by special train to Ampere and return, taking about forty minutes each way, from Barclay or Christopher street ferries, and about one and one-half hours would be required for the inspection; the time of starting and the date, of course, to be arranged by you, to suit the convenience of the members.

"The improved direct applications of electric power to all of our machine tools, and our methods of operating the entire plant by electric power, will be found of great interest.

"Our works have been recently rebuilt, embody all the most modern features for a manufacturing plant, and are said by the New England Mutual Insurance Company to be about the finest plant in the country.

"We recently had a visit from the American Society of Civil Engineers, during their annual convention, and they found the trip of very great interest.

"Yours very truly,

"CROCKER-WHEELER ELECTRIC CO.,

"S. S. WHEELER,

"President."

THE PRESIDENT: In addition to this letter, I will say that the company has placed in the hands of the secretary a number of invitations, each invitation inclosing two tickets over the Delaware, Lackawanna and Western Railway to Ampere, New Jersey, the location of their factory, and that those tickets are good for the members or their friends who are with them, and can be obtained upon application at the secretary's office.

I have another communication which I will read, dated May 4th, and addressed to the secretary of the National Electric Light Association:

"My Dear Sir: Mr. DeWolf Hopper has designated next Wednesday evening at the Broadway theater as 'Electric Night,' in honor of the visiting delegates of the National Electric Light Association, now in session in this city. A special performance of the latest comic opera novelty, entitled 'El Capitan,' will be given, and the night will be made a memorable one. Mr. Hopper, who is remarkably clever at interpolation, will be very apt to spring several happy electrical surprises upon the many promoters of electricity who will be present, and the bright and witty libretto will fairly bristle with dynamos of wit and sparkling humor.

"The Broadway theater upon this occasion will be ablaze with light, and the night, no doubt, will be a most memorable one.

"Kindly announce this event to your visiting delegates and others, and say that a major portion of the orchestra and orchestra-circle, containing the choicest seats in the house, have been laid aside, and can be secured upon application at our box office.

"Yours very truly,

"J. W. McKinney."

THE PRESIDENT: The next in order on the programme is Mr. L. A. Ferguson's paper on acetylene gas.

Mr. Ferguson read the following paper:

THE COMMERCIAL VALUE OF ACETYLENE GAS AS AN ILLUMINANT

Mr. President and Gentlemen of the National Electric Light Association: It is my intention in presenting this paper to treat of acetylene in its commercial aspect as related to the illuminating industry, and to attempt no description of its value in the chemical world, as the latter is a field entirely apart from that invaded by this association, and one so comprehensive that it might well be made the subject of another discourse.

The first step in the process of manufacture of acetylene gas is the production of calcium carbide, which is accomplished by the reduction of lime by carbon with the intense heat of the arc in an electric furnace. The chemical equation representing the action is $CAO+3C=CAC_2$, the CAO representing the lime, 3C the carbon, CAC_2 being the symbol of calcium carbide, and CO carbonic monoxide. Although several experimenters produced carbide of calcium and carbide of sodium, and from these acetylene gas, many years ago, the first production of carbide of calcium on anything like a commercial scale was made by Mr. T. L. Wilson, at Spray, N. C., while endeavoring to produce the metal calcium in the electric furnace. It was my good fortune to have visited with Mr. Wilson his plant at Spray, and there carried on experiments in the manufacture of the carbide of calcium and the production therefrom of acetylene gas, and perhaps a few words in description of the apparatus employed may be of interest to you.

Spray is a beautiful little spot about twenty-five miles southwest from Danville, Va., and about two miles from Leaksville, N. C. It is reached from Danville by a narrow-gauge road, operated by the negroes, a locomotive boiler being fired by wood in true primitive fashion, the roadbed hardly being the equal of the trunk lines between New York and the West. The carbide plant is located alongside of a small stream, which has quite a fall at this point, the power of the fall driving a Leffel water wheel to which are belted two 120-kilowatt alternating-current dynamos built for sixty cycles per second. In Mr. Wilson's original work he used a direct-current dynamo of his own construction, but this was abandoned later and the larger alternating-current machines purchased, so as to enable the experiments to be carried on upon a larger scale. It was also imagined that an alternating-current dynamo would give better results, it being claimed that the alternating current would keep the mixture of coke and lime stirred up about the arc. This, of course, was a fallacy, the real value in the use of the alternating-current machines, as compared with the original ones built by Mr. Wilson, lying in that no commutator being required, it was much easier to regulate under the varying conditions of the arc, and there was an entire absence of sparking, which was a destructive feature of the original dynamo. The alternators are built for 1,000 volts, arranged to run in parallel, and transformers are used to bring the pressure to one hundred volts. The switchboard for the dynamos is provided with ammeters and voltmeters for each dynamo, so that the output may be accurately determined. From the switchboard, large cables, capable of carrying 1,000 amperes, run to each of two furnaces which are built of brick, the dimensions of the furnace being approximately three feet square and eight feet high. Each furnace is provided with a flue to carry off the gases of reduction. In the floor of each furnace is a carbon plate to which the cables connect, this plate constituting one pole of the arc. The upper carbon for the arc consists of six carbons in one cast-iron holder, each carbon being four inches square in cross section and thirty-six inches long, and weighing each thirty-five pounds. The carbons are raised and lowered by means of a chain winding on a drum operated by a wheel in the dynamo room, so that the energy expended in the production of the arc is maintained constant during the process of manufacture of the calcium carbide. Having thus seen the method of producing electricity and its application to the electric furnace, we will now pass to the process of manufacture of the carbide.

The carbon used in the process at Spray is Pocahontas coke, having a nine per cent ash. The coke is conveyed to a hurricane mill, where it is ground to a fine powder, and then put with the lime into a revolving mixer, by which it is thoroughly mixed and prepared for the electric furnace. Theoretically, the proportions of lime and carbon necessary for the production of one hundred pounds of calcium carbide are eighty-seven and one-half pounds of lime and fifty-six and one-quarter pounds of carbon. These, combined according to the formula before mentioned,

$CAO+3C=CAC_2+CO$, thirty-seven and one-half pounds of carbon combining directly with the metal calcium, forming calcium carbide, and eighteen and two-thirds pounds combined with the oxygen of the lime, forming carbon monoxide gas, which passes off from the furnace.

Nearly twelve months ago, on May 15th, 1895, at Spray, N. C., with the described plant, the writer, together with Mr. Geo. O. Knapp, of Chicago, and T. L. Wilson and Major Morehead, of Spray, N. C., carried on a test to show the actual production of calcium carbide per horse-power per day and the volume of acetylene obtainable per pound of carbide. The coke and lime were prepared in the manner described, the mixture containing 800 pounds of air-slaked lime and 390 pounds of powdered coke, making the total weight of mixture 1,190 pounds. Of this mixture, 180 pounds were unused, leaving 1,010 pounds, which were delivered to the furnace. The test run was for a period of three hours, during which the mixture was fed into the furnace by shovel, as required, and the material stoked regularly. The current used varied from 900 amperes to 1,200 amperes, as extreme limits, but being kept very regularly at about 1,000 amperes, the voltage varying from ninety to 104 at the extreme, and being kept fairly constant at one hundred volts. Readings were taken approximately every ten minutes during the test, and from twenty-three readings the average showed 1,000 amperes and one hundred volts, or an average consumption of energy at the terminals of the furnace of one hundred kilowatts during the entire run of three hours.

After the current is turned on and the arc made, the carbide begins to form on the bottom of the furnace under the upper carbons in the shape of a block, and as it forms it is necessary to raise the upper carbons to maintain the proper arc, the current passing from the carbons in the form of the arc to the carbide below, the latter now constituting the other pole of the arc and conducting the current to the plate in the bottom of the furnace. The production of the calcium carbide is by the heat of the electric arc alone, and not by electrolysis, the temperature of the arc being in the neighborhood of 3,500 degrees to 4,000 degrees C., while that of the ordinary smelting furnaces ranges from 1,200 degrees to 1,500 degrees.

At the end of the run the current was cut off, the furnace allowed to cool down, and the product and unused material removed and carefully weighed. During the production of the carbide some of the mixture is lost by passing up the chimney with the gases of reduction, which burn with wild sheets of flame, increasing with their hissing the already deafening roar of the immense alternating-current arc. The weight of the calcium carbide actually produced in this test was 139 pounds, the unused material amounting to 607 pounds, to which must be added the water contained in the lime—165 pounds—making the total unused material 772 pounds. The weight of the mixture delivered to the furnace was, as stated before, 1,010 pounds, so that the actual weight of mixture consumed and lost in the process of manufacture of 139 pounds of calcium carbide was 238 pounds. The efficiency of production, therefore, would be the weight of carbide produced divided by the weight of mixture used up, or 139 divided by 238, which gives fifty-eight and four-tenths per cent as the efficiency of production.

The next step is to calculate from the results of the tests the amount of carbide produced per kilowatt hour. We have seen that the average value of the energy expended in the production of the carbide was one hundred kilowatts, and that we produced 139 pounds of carbide in three hours, or at the rate of forty-six and one-third pounds per hour; therefore, the carbide produced per kilowatt hour would be forty-six and one-third divided by one hundred, which is forty-six-one-hundredths pound, or at the rate of 11.12 pounds of carbide per kilowatt per twenty-four-hour day, or 8.3 pounds per horse-power per day of twenty-four hours. A sample of this carbide produced, weighing 34.1 grammes, was then taken, and the acetylene gas formed by adding water, and the gas evolved, measured by means of special apparatus, showed a result of 5.24 cubic feet of acetylene gas per pound of carbide, after making the proper temperature and barometric corrections.

Having thus seen the quantity of calcium carbide produced for each kilowatt hour of energy consumed, and the value of the carbide as a producer of acetylene, we will now take up the method of production of acetylene from the carbide and consider some of its properties before determining the cost of production of the carbide.

Acetylene is produced from the calcium carbide merely by the application of water, the action being shown by the equation: $CAC_2+2H_2O=CAOH_2O+C_2H_2$. When the carbide is thus brought in contact with the water, the acetylene gas is driven off rapidly, and its presence is distinguished by its very pungent odor, somewhat resembling phosphorus. When lighted, it burns with a deep yellow flame and is extremely sooty; but when generated at an even pressure, and burned with proper burners designed for the use of acetylene, it gives a beautiful white light. The acetylene flame so used is exceedingly tenacious, and it is almost impossible to blow it out, which may be considered as an advantage in hotels and other places where rural gentlemen occasionally take up their abode.

A simple method of generating acetylene from the carbide is the following: Take an ordinary chlorine generator and place within some lumps of the carbide, arrange a glass funnel so that water may be admitted to the interior of the generator, connect the generator by means of a rubber tube to a gasometer, the outer tank being partially filled with water; from the gasometer, above the water line, another tube connects to a gas pipe with a set of burners attached. Water is then poured gradually in small quantities through the funnel into the generator and upon the carbide. The acetylene gas thus generated passes through the tube to the inside of the gasometer and lifts the gas holder, the position of the latter changing with the quantity of gas generated. The gas is then delivered from the holder by means of the rubber tube to the piping and burners. As the gas is consumed, the holder lowers and a fresh supply is generated by admitting more water through the funnel upon the carbide within the generators.

Another method, which is automatic in its action, is to partially submerge a vessel in water, the vessel being open at the bottom and containing the carbide suspended on a screen in the upper part of the vessel. The gas is then drawn from above the carbide, and, as long as it is being used, the water remains more or less in contact with the carbide; but as soon as the consumption of gas ceases or diminishes, the pressure of the gas forces the water downward into the lower part of the vessel and away from the carbide, thus causing the generation of the gas to cease. An arrangement similiar to this is one proposed for country residences.

Acetylene gas may also be used in its liquid form, and is prepared by decomposing the calcium carbide with water in a closed vessel and conducting the generated gas under pressure to a condenser, where it liquefies, and is then drawn off in tanks for shipment and distribution.

Compared with other gases, acetylene has a very high candle-power. Water gas, which is used in nearly all the large cities of the United States for illuminating gas, when burned at the rate of five cubic feet per hour, gives from twenty to twenty-five candle-power, while acetylene, when burned at the rate of five cubic feet per hour, gives, according to most observers, 240 candle-power, or, approximately, ten times the illumination of water gas.

The temperature of the acetylene flame is low as compared with that of water and coal gas, Professor Lewis placing the temperature of the acetylene flame at 1,000 degrees C., and the coal gas flame at 1,360 degrees C. It has been stated by Professor Crafts, of the Massachusetts Institute of Technology, that the true relation of the temperature of the present commercial illuminants, when giving the same candle-power, is: Incandescent light, 1; acetylene, 3, and water gas, 9; showing that the incandescent lamp gives off the least amount of heat per candle-power, while acetylene gives three times that of the incandescent lamp and one-third that of water gas.

Many experiments have been made by noted scientists and investigators, to determine the poisonous qualities of acetylene gas. Guinea pigs, dogs, and other animals have been made martyrs to science and subjected to mixtures containing carbonic oxide, which is the poisonous constituent of ordinary illuminating gas, and after their death their blood has been examined and the amount of carbonic oxide absorbed by the blood determined. Grehant made comparisons of carbonic oxide and acetylene, to determine their relative poisonous qualities upon dogs. In his experiments he used twenty per cent of oxygen in his mixtures, so as to prevent the animal's death by suffocation. He added enough Paris illuminating gas, which contains seven per cent carbonic oxide, to give one per cent carbonic oxide in the mixture. The dog showed signs of suffering after three minutes, and in ten minutes the dog was very sick, and his blood showed twenty-seven volumes in one hundred of carbonic oxide. Another dog was subjected to a mixture containing twenty per cent oxygen and twenty per cent acetylene, and the dog breathed without inconvenience for thirty-five minutes. Upon examination, his blood showed ten per cent acetylene; less than one-fiftieth the rate of absorption of carbonic oxide. The mixture contained much more acetylene than that to which a person could be subjected in the use of acetylene as an illuminant, since a leak of the gas would produce an explosion in the room of a dwelling-house before the percentage of acetylene mentioned were attained in the atmosphere. Similar experiments were carried on by Brociner, Berthelot, and Claude Bernard, and the conclusions of the best authorities indicate that acetylene, when pure, is not poisonous. Berthelot has pointed out that the old method of preparation of acetylene by means of acetylide of copper may contaminate the gas with hydrocyanic acid and thus render it poisonous.

Having seen how the calcium carbide and acetylene are made, and having considered their properties, the question now before us is the cost of producing them. The results of the tests made at Spray, and before described, show that 8.3 pounds of carbide are produced by each electrical horse-power in one day, or, .463 pound per kilowatt hour; also that the efficiency of production was 58.4 per cent. Experience at Spray shows that the carbons used as electrodes last about seventy hours with the same amount of energy as used in this test. The cost of these carbons is $2.00 each; which approximates six cents per pound, or eighteen cents per kilowatt hour. The cost of lime I have put at $5.00 per ton, and coke at $2.50 per ton; these figures being about the average prices for these materials of good quality, and considerably less than the actual cost of them at Spray. The question of the cost of electrical energy is the all-important one, so I have taken the Niagara price of $20.00 per electrical horse-power per year of 8,760 hours, considering this to be the lowest commercial price obtainable at the present time, and one which offers no question as to its accuracy, it being one which is absolutely tangible.

The estimate is further based on the assumption that the carbide plant is to be operated at full load twenty-four hours per day and 365 days each year, so that the actual cost per electrical horse-power hour of energy consumed may not exceed $20.00 divided by 8,760, which is .238 cent, or .317 cent, per kilowatt hour. With these data as a basis, the cost of producing one ton of calcium carbide at Niagara Falls, in a plant having ten 200-kilowatt furnaces, producing ten tons of carbide per day, would be as follows:

POWER

4,320 kilowatt hours at .317 cent per kilowatt hour	$13.69

MATERIALS

2,085 pounds of lime at $5.00 per ton	5.21
1,339 pounds of coke at $2.50 per ton	1.67

CARBONS

Carbons for 4,320 kilowatt hours at 18 cents per kilowatt hour	7.78

SUPERVISION AND LABOR

Operating two shifts, 12 hours each:

1	superintendent at	$5.00	$5.00
1	chemist at	4.00	4.00
2	foremen at	2.50	5.00
10	regulating men at	1.00	10.00
6	furnace men at	1.50	9.00
2	grinders at	1.50	3.00
6	laborers, handling, grinding and mixing, at	1.50	9.00
			$45.00

Labor, per ton, $45÷10	4.50
Cost of barrels and preparing carbide for shipment	1.00
	$33.85

Interest at 6 per cent on $25,000, the investment necessary to erect the factory, furnaces, crushing and mixing machinery, apparatus for handling and regulating,	$1,500.00	
Depreciation on $25,000 at 5 per cent	1,250.00	
Taxes at $10 per $1,000	250.00	
Insurance at $3.00 per $1,000.	75.00	
	$3,075.00	.84
Cost of production at Niagara		$34.69
Freight from Niagara to New York, Philadelphia, Boston, or Chicago, at 15 cents per 100 pounds		3.00
		$37.69

This estimate of cost per ton of calcium carbide is intended to represent the cost of manufacture to a large gas company operating in New York, Boston, Philadelphia, or Chicago, with its calcium carbide works at Niagara, and whose business would be to produce acetylene from the carbide in the city where the gas is to be used, and to distribute it to its customers through its existing mains. It is not intended to represent the cost cleared off its books of any corporation or firm whose sole business would be to manufacture calcium carbide for the market, for to cover that case we must add to the above estimate the cost of general expense, including administration, royalties, and selling expenses, which, of necessity, would be equal to a large percentage of the factory cost as given. Let us, then, consider the value of acetylene to the gas companies in large cities. In many articles and circulars treating of this question, it has been customary to place the actual cost of acetylene as produced from the carbide, taking the factory cost of the carbide as the basis, against the selling price of illuminating gas at $1.00 per 1,000 cubic feet. This, of course, is not a fair comparison and is very misleading. Believing that the only fair way to consider the relative values of acetylene and water gas is to compare them on the basis of cost per candle-power hour in the holder; and, assuming that the cost of distribution is the same in each case, I will treat the question on that basis.

We have seen from the results of the tests at Spray that for each pound of carbide we obtained 5.24 cubic feet of acetylene, or 10,500 cubic feet per ton; therefore, the cost per 1,000 cubic feet of acetylene would be one-tenth the cost of one ton of calcicum carbide. The candle-power of acetylene being placed at 240 for each five cubic feet of gas, and the candle-power of water gas in the large cities at twenty-five for each five cubic feet of gas, it will be seen that the candle-power of acetylene is ten times that of water gas per 1,000 cubic feet, and, therefore, the cost of acetylene, giving the same candle-power as water gas, would be equivalent to water gas at a cost per 1,000 cubic feet equal to one-one-hundredth of the cost per ton of calcium carbide. For example, if the calcium carbide costs the gas company $100.00 per ton, then the cost of acetylene gas in the holder will be equivalent to twenty-five candle-power water gas costing $1.00 per 1,000 in the holder.

The present average cost of illuminating gas in the holders of the large gas companies approximates thirty cents per 1,000 cubic feet, while the cost of acetylene gas in the holder with calcium carbide at

$37.69 per ton would be equivalent, light for light, to illuminating gas at thirty-seven and seven-tenths cents per 1,000 cubic feet, making the cost per candle-power hour of pure acetylene approximately twenty per cent higher than that of ordinary illuminating gas. If acetylene were mixed with air and distributed, the cost would be less. This has been done in an experimental way, using sixty per cent acetylene and forty per cent air; but the advisability of attempting to distribute such a mixture through a system of mains in a city, for commercial use, is exceedingly questionable, owing to the risk of the mixing being improperly done and the quantity of acetylene falling to such a percentage as to form an explosive mixture.

It has been suggested that the cost of distribution, as well as the cost of mains and maintenance, which constitute a large portion of the cost in the lighting industry, might be saved by the use of liquid acetylene, put up in cylinders and delivered to the stores, residences and offices, so that the consumer might generate his own gas as required. It appears to the writer that this method is an entirely impracticable and uncommercial one, as there are almost insurmountable objections to be overcome. Neither the average business man nor the occupants of a residence wish to be bothered with the care necessarily attendant upon the use of the cylinders of acetylene. It would be necessary, either to have two cylinders ready for service, or to have a second one placed in service before the first one were exhausted, and, in all probability, the busy man would find himself in darkness at the time when he most needed the light, owing to the fact that he had neglected to renew his cylinder. The pressure of the gas in these cylinders is from 600 to 700 pounds, so that it is necessary to use a reducing valve that will give a pressure of one ounce. The same valve that is used with the Pintsch system of railway lighting is employed, but this, in all probability, would not be kept in condition by the ordinary householder or storekeeper, and the consequence would be that the full pressure might be impressed upon the pipes, and in case this were prevented by the use of an auxiliary safety valve, then every failure of the reducing valve would allow all the gas to escape and be lost. The use of acetylene cylinders would increase the danger in case of fire, since the gas would escape should the cylinders become heated, and explosions of the mixture of acetylene gas and air would possibly follow. After considering the many inconveniences and dangers in the use of liquid acetylene in the business and residence districts of the large cities, the writer is led to believe that acetylene, to be commercially successful, must be delivered to the customers in a form of gas through a system of mains, as is now done with ordinary illuminating gas. Liquid acetylene should find a field in the lighting of country estates, railway trains, and for use in carriage, bicycle and locomotive head lamps, and in isolated places where distribution by mains is not possible.

When acetylene was first brought forward to be used commercially, it was expected that the gas companies might still maintain their existing gas works and use acetylene to enrich their gas and furnish a twenty-five candle-power flame as formerly, but at a much less cost. Experiments have shown, however, that, although coal gas may be enriched by acetylene, water gas is not susceptible to enrichment through it. Water gas, which is furnished in nearly all the large cities, has little illuminating power of its own, is now treated with petroleum, and it is only when enriched to a certain candle-power that acetylene may be mixed with it without losing its candle-power; so that we cannot, as at first supposed, substitute acetylene for petroleum, and use it economically as an enricher of low candle-power water gas.

It has been suggested that the manufacture of calcium carbide might be carried on by the central station electric lighting companies as a by-product, furnishing the energy necessary for its production during the hours of light load upon the lighting system, thus bringing the load curve of the station nearer to a straight line, and thereby improving the economy of the station operation. It will readily be seen from the figures given in the estimate of the cost of producing the carbide, that the cost of power is a very important factor, and if we increase the cost given, of $20.00 per horse-power per year, we shall correspondingly increase the cost of the carbide. From experience of the cost of operation of the largest central lighting stations in this country, the writer can safely state that the absolute cost of fuel alone in the most economically operated lighting station of the most modern type of multiple expansion condensing plant, averages .3 of one cent per kilowatt hour, or, approximately, $20.00 per horse-power per year, continuous service, while the total cost of generation in the station would average over double that amount. In the average of the large central stations, the generating cost at the switchboard, without distribution and general expenses, approximates one cent per kilowatt hour, which is about $65.00 per horse-power per year, and, in smaller stations using steam, double that amount. It is obvious, then, that we may not hope to use our present central stations during minimum hours for the manufacture of calcium carbide as a by-product while the cost of power in our stations remains as it is at present, and the amount of power required for the production of carbide so excessive, as the cost of its production by the central station would be prohibitive. It would be much better and more profitable for the central station manager to sell his electrical energy through the incandescent or arc lamp at the same price per kilowatt hour than to use the energy for the production of carbide, since the cost per candle-power hour would be less when the electrical energy is converted into light directly through the incandescent and arc lamps than through calcium carbide and pure acetylene, assuming the cost of distribution and general expense to be the same in each case. Take, for example, carbide at $40.00 per ton, which means forty cents' cost per 5,000 candle-power hours of acetylene gas in the holder, or 125 candle-power hours for one cent. Compare this with electrical energy at the switchboard at two cents per kilowatt hour. For each kilowatt hour generated, we obtain twenty fifty-watt incandescent lamps, each giving sixteen candle-power, making a total of 320 candle-power hours per kilowatt hour, or 160 candle-power hours for one cent, which is twenty-eight per cent more candle-power for the same expenditure of money by the use of the incandescent lamp directly as a converter of electrical energy into light as against the conversion by means of carbide of calcium and acetylene.

If we take the case of the arc lamp and add to the cost of the electrical energy 1.5 cents per kilowatt hour for carbons, trimming and repairs, making the total cost 3.5 cents per kilowatt hour, we find it still more advantageous. Assuming that a 500-watt arc lamp gives 1,000 candle-power, we have 2,000 candle-power hours per kilowatt hour, or 575 candle-power hours for one cent, which is 4.6 times the illumination for the same money as compared with pure acetylene gas.

Taking the cost per kilowatt hour at the switchboard in the large central stations, we obtain 320 candle-power hours for one cent, which is 156 per cent more candle-power for the same expenditure of money by the use of the incandescent lamp directly as a converter of electrical energy into light as against the conversion by means of carbide of calcium and acetylene.

By means of the arc lamp, on the basis of cost of one cent per kilowatt hour for electrical energy and 1.5 cents per kilowatt hour for carbons, trimming and lamp repairs, we obtain 800 candle-power for one cent, or 6.4 times the illumination for the same money as compared with pure acetylene gas.

From these deductions and considerations, gentlemen, it may be concluded, in the light of our present knowledge and upon the basis of the estimated cost of production of the calcium carbide, that acetylene gas should not drive the incandescent and arc lamps from the lighting field, neither should it make such inroads on the electric lighting business as to materially affect the earnings of existing central station companies; for, after all, acetylene is a gas, and burns with a naked flame, and the use of incandescent and arc lamps has steadily increased year by year, not because of their cheapness, but because of their infinite superiority as illuminants over any gas flame yet developed.

DISCUSSION

THE PRESIDENT: Gentlemen, we have heard an extremely interesting and able paper by Mr. Ferguson, on the subject of acetylene gas. I should like to hear from any gentleman present who may have any remarks to make upon the subject. I should like to hear from Mr. Nicholls, who has had some experience in the manufacture of it.

MR. NICHOLLS: Mr. President, I am not in a position to give any very general details in connection with the subject. There is one question, however, that I should like to ask Mr. Ferguson, and that is regarding the transportation in barrels. I see that he has fixed a certain price for barrels, etc., and it occurred to me that if it had to be shipped in large quantities, it would have to be placed in hermetically sealed packages. From what experience I have had, I do not believe it would be safe to ship it in barrels. I know that the slightest moisture seems to affect it, and in much the same manner in which lime is affected by moisture. One drop of moisture on acetylene will cause the gas to generate quickly; and if that came in contact with a flame—in case it were alongside a freight car, for instance—I think it might prove disastrous. I have not had any practical experience in the matter, other than having seen the effect of it in that way, and I should like to ask Mr. Ferguson if he has examined that aspect of the case.

MR. FERGUSON: Mr. President, I should like to say that I do not think anybody has had any experience in the actual shipment of it, but I have no doubt Mr. Nicholls is quite right in his assumption. The estimate I have made is probably very low as to the cost of barrels and the cost of shipment; but, as it was such a small item, I thought I would put it on that basis, which would cover the cost of ordinary barrels of sufficient strength to contain the calcium carbide; whereas, in all probability, in actual practice you would have to use hermetically sealed tins or irons of some kind.

MR. BEGGS: Mr. President, I think the paper presented by Mr. Ferguson is one of the most comprehensive, exhaustive and intelligent treatments of the matter, both from a manufacturing and a competitive commercial standpoint, that I have seen presented upon the subject, and I have tried to read much in connection with this matter. It thoroughly confirms what have been my own impressions and calculations. I think, therefore, Mr. President, that this association should extend to Mr. Ferguson a hearty vote of thanks for the very great care with which his paper has been prepared, and I move that in connection with such vote of thanks the secretary be directed to have the paper printed in pamphlet form, with the least possible delay, and a number of copies sent to each of the members of this association. It is a matter that is receiving a great deal of attention, and it is a source of much worriment at many central stations as to how much of a competitor acetylene gas is going to be in their particular business. My motion is, that the paper be printed in pamphlet form and in advance of the minutes. I think it should be brought out with a little more promptitude than the minutes usually are.

The president put the question upon the motion of Mr. Beggs, and it was carried unanimously.

PRESIDENT WILMERDING: Is there any further discu this subject?

Mr. Beggs: I think, Mr. President, that Mr. Ferguson's discourse upon the question is so full and exhaustive, that there is very little else to be said.

The President: That is true. We will consider the discussion closed.

THE PRESIDENT: The next item on the programme is a paper by Mr. F. H. Leonard, Jr., on single-phase, self-starting, synchronous motors.

Mr. Leonard read his paper as follows:

SINGLE-PHASE, SELF-STARTING, SYNCHRONOUS MOTORS.

Every central station manager who operates an alternating plant has to grapple with the question of power distribution. Applications for power service come in from every direction, and, in many cases, properly worked up, would make a more remunerative business than that of furnishing current for lighting purposes. It is, perhaps, unnecessary to point out that the bulk of the lighting service averages but a few hours per day, whereas the motor service covers a much longer period, with a corresponding reduction in cost of the current output. The difference is so great that many stations are furnishing current for motor service at fifty per cent of the price for lighting service, and, even then, figure that the motor business is the more profitable.

To secure this business and meet the demand for power service, many of the alternating stations have installed special 500-volt, direct current generators and erected additional lines; but such a system is limited by the expense of such extension, necessarily paralleling other lines already constructed for lighting service. Under such conditions, a remunerative piece of business is often refused on account of the first cost of [illegible] necessary to reach the customer.

The many advantages of the single-phase, alternating current system have led to its adoption in the great majority of the central lighting stations of the United States, notwithstanding the objections that (aside from a few inefficient fan motors of a fraction of a horse-power) no motors practical for general power distribution were obtainable for use on this system. This objection, however, no longer obtains, as there are alternating current motors now made to operate on the single-phase circuits from ordinary lighting transformers, without the use of special starting devices, condensers, or connections, which not only equal the best direct current motors in commercial efficiency, but are superior to them in point of regulation, reliability, and freedom from burn-outs. With such a motor, which can also be used as a rotary transformer, the single-phase alternating system has every advantage of the low tension, direct current system, besides which it is much superior in simplicity, flexibility, and adaptability for long distance distribution ; so that to-day arc and incandescent light, heat, and power are distributed from the alternating system at a distance of a fraction of a mile, or at thirty miles or more, controlled, regulated, and metered with equal facility and perfect satisfaction to the consumer.

The single-phase, alternating current motor has been to the electrician, like the panacea of the alchemist, the cause of almost endless thought and experiment ; but the solution of the problem was a most simple one, and rests on two well-known principles. Attempts have been made to use induction motors on the single-phase circuits, but it is difficult to start them, and usually very cumbersome and expensive arrangements have been devised which give but small starting torque. Besides this, in order to make them at all efficient and keep the power factor within reasonable limits, a very small clearance or air gap (often as little as one-quarter millimeter or $\frac{1}{100}$ of an inch) must be allowed between fields and armature, so that the slightest mechanical wear or vibration causes trouble. Even under the most favorable conditions, it is impossible to construct an induction motor so as to avoid a very considerable lagging or so-called "wattless" current. In such motors, the power factor, which in the ratio of the real to the apparent energy, varies from twenty to eighty per cent. That is to say, if the motor has a power factor of fifty per cent, there must be double the current furnished that is actually required to do the work, and, while half the current is wattless, yet it uses up capacity in generator, transformer, and line wire, with energy consumption due to C^2R losses in each, and in long-distance transmission, the impedance (which is the ohmic drop plus that due to the inductance of the line, and which varies with the current and frequency) cuts such a figure as to make the expense for copper large, in order to keep the working electromotive force within proper limits.

Pacinotti's discovery of the reversibility of a dynamo applies to alternating current machinery as well as direct, except that the ordinary alternating current generator, when used as a motor, must be brought to synchronous speed before it will fall in step with the generator, and, further, must have its fields excited with direct current, usually from a separate source. It will then operate as a motor, and is the most satisfactory motor that can be produced when constant speed is required. Its efficiency is the highest; quite as high as that of direct current motors of equal capacity, while the regulation is perfect. So long as the generator with which such motor is connected runs at a uniform speed, the motor must run at a proportional speed, dependent on the ratio of the poles to the alternations; every impulse of the generator advancing the armature of the motor one pole. The motor cannot change its speed any more than if it were mechanically geared to the generator, unless it is overloaded to a point where it is impossible to carry the load, which point is usually about fifty per cent in excess of the normal capacity of the motor. This is accomplished without the introduction of any lag or power factor, the load being practically non-inductive—like a load of incandescent lamps—provided the proper excitation is maintained. Furthermore, by overexcitation the synchronous motor may be made to perform the office of a condenser and compensate for lag or inductive load, and can be carried so far as to induce a negative lag or load, at the same time raising the electromotive force of the line.

The drawback to the single-phase synchronous motor has heretofore been that it could not be started without some other source of power, and would not carry its load up to speed. This is entirely overcome. Motors are now made in which they start up under load, and can be specially wound to give much greater torque in starting than when running in synchronism.

This brings us back to the two simple, well known principles before referred to, which are combined in this motor; the principle of the ordinary alternating current synchronous motor with that of the direct current motor or generator. The armature has two distinct windings; one, a distributed winding connected to a commutator, similar to that of a direct current motor or dynamo, which in this motor is used for starting and afterwards for exciting the fields. The other winding is of the shuttle type, wound so as to concentrate distinct and regularly alternating poles in the armature, and performs the regular work of rotating the motor armature, advancing it from one pole to the next, with each impulse of the generator.

An ordinary double-throw switch on top of the motor is used in starting, there being no resistance or other complicated device, as the self-induction of the windings is sufficient to choke back any abnormal flow of current. In starting, the switch handle is depressed so that the lead wires which conduct the alternating current from the transformer are connected through the switch blades to the contacts that lead the current first to one of the commutator brushes, thence through the distributed armature windings and out through the opposite brushes to a coarse wire winding on the field poles and back again to the switch contacts and binding posts; these connections being identical with those of a direct current series motor. As soon as the current is turned on, the motor commences to rotate at a constantly accelerating speed until synchronism is reached, which is indicated by the lighting of a lamp, located on the switch, at a dull red. This is the signal for the reversal of the double-throw switch, which then changes the connections so that the leads from the transformer are cut off from the commutator and connected to the collector rings and concentrated armature windings, while, at the same instant, the commutator brushes are connected to the shunt field windings, magnetizing the field with direct current; the only office of the commutator, after the motor is started and up to speed, being to supply the small direct current necessary to magnetize the fields.

In starting without load, the motors will run up to synchronous speed in from five to fifteen seconds, depending upon size, windings, etc., and when loaded, in from fifteen to thirty seconds, taking about the same current in either case, the time factor making the difference in power consumed; the current taken under these conditions amounting to from twenty-five to fifty per cent in excess of what the motor will require when running in synchronism. But when only required to start itself or light countershafting, this current may be greatly reduced by special windings.

The direct current winding delivers a perfectly smooth current, and is not at all pulsating in character. In circuit with the field winding is a rheostat to control the extent of field excitation. This rheostat is located in a recess in the base of the motor, the handle for its regulation being accessible through the oval opening at the commutator end pedestal. The motor-starting switch and field rheostat are in one piece, making a most simple and compact combination. All that is necessary to install the motor, is to connect the secondary wiring of the transformer to the two binding posts on the motor, and it is ready for operation.

The general design of the machine is substantial and symmetrical, with graceful curves sweeping from point to point, giving the motor a very pleasing appearance. Nothing has been spared in the design and construction of these motors to make them as perfect as possible, and the motors are evolved from a careful consideration of the two years' practical operation of a similar motor, after which a thorough course of experiment was instituted and carefully tabulated, to determine beyond a doubt the accuracy of the calculation for the new design. Careful attention has been given to every detail that would tend to make the motor neat in appearance and simple, so that the man without previous training, into whose hands a motor usually falls, would have no difficulty in its use.

The mechanical perfection of any piece of machinery is the all-important one, and in this motor has been given the full attention it deserves. The best engineering practice of the day has been followed, and where any departure has been made, it has been to make the construction more rigid and capable of resisting overload and excessive strain. The bearings are of bronze, self-aligning and self-oiling; two small rings, traveling in recessess in the boxes so that they touch the top of the shaft, the rotation of which carries the rings around, lifting, as they turn, enough oil from the chamber below the bearings to keep the shaft abundantly lubricated. As the oil is used over and over again, a single filling furnishes lubrication for months; and as the oil gets low, the rattling of the rings serves as a warning that the oil should be replenished.

The field crown is of the multipolar type, with field cores pointing inwardly; the magnetic circuit is composed of sectional sheet-iron punchings, each section including two poles, stacked so as to break joints. These punchings interlock, and are clamped between two cast-iron rings with bolts passing through from side to side, which serve to clamp the whole together solidly, at the same time holding each punching in its proper place and tying them like links in an endless chain. The bottoms of the cast-iron rings are milled to fit the base of the motor, to which they are firmly bolted.

On top of the field crown is placed a starting switch, and all the electrical connections from fields, commutator and collector brushes are brought around the outside of the field punchings to the top, concealed from view, however, by the perforated steel jacket, which is held in place by grooves in the cast-iron clamping rings, forming an ornamental finish and greatly increasing the radiating surface.

The binding posts for the motor are located at the centre line of the switch. Any inside wireman that has connected incandescent lamps will have no difficulty in wiring and connecting one of these motors, as the work is precisely the same as for a two-wire lighting service. The primary wires are connected through a primary fuse box to the transformer. The secondaries of the transformer, which are perfectly insulated from the high-tension primaries, carry the low-tension currents which are induced in the transformer through the fuse box, which is provided as an extra safeguard against the accidental flow of any dangerous current; and from there to the double-pole knife switch, which is used to turn the current on and off from the motor. From this switch two wires connect to the binding posts of the motor. There is no multiplicity of wires or special connections for starting box to perplex one.

The purposes to which these motors are applicable are almost without end; ranging from commercial use in labor-saving devices, such as printing presses, type-setting machines, lathes, machine tools, elevators, laundry, sewing machines, pumps, ice cream freezers, church organs, coffee mills, sausage machines, etc., down to twirling the ceiling fans in a restaurant, where you can enjoy a comfortable meal in the heated months, or to driving a "merry-go-round" on which the children, and often the older ones, delight to ride on a holiday in the public parks or at the sea shore.

As this motor runs at a constant speed, it has been necessary to devise several special arrangements to accomplish what might be done by a variable speed motor. Motors are made for blowing church organs, in connection with which it has usually been customary to provide complicated automatic speed-regulating devices. With this motor, no attempt has been made to vary the speed, but, instead, a pressure fan blower has been driven at constant speed. The organist closes his circuit and starts his motor by means of a pedal. The blower, driven by the motor, fills the bellows and maintains a constant pressure, usually about four ounces per square inch. If no air is used, the blower spills the wind out of its fans and requires only enough power to overcome the friction and maintain the pressure. As fast as the air is used, the blower takes a corresponding amount of power, the motor absorbing current accordingly.

An extremely simple arrangement for elevator service has been devised. The constant speed alternating motor, cable drum and gearing are all mounted on a single base casting, to which the respective parts are bolted. There is a pinion on the shaft of the motor which engages two bevel gears, each mounted on a sleeve, which also carries one part of a friction clutch, the two sleeves rotating in opposite directions, and the whole being supported by, and turning freely on, the worm shaft that engages the worm wheel that turns the cable drum. The other part of each clutch is keyed to the worm shaft. The controller wheel is mounted on an extension which is cast on the case that entirely incloses the bevel gears and pinion, permitting them to run constantly in oil. This controller wheel is connected to the controller cables, or hand ropes, which serve to operate the elevator. A pull on the hand rope turns the controller wheel, rotating it through an arc of sixty degrees. This rotation serves, first, to release the brake on the worm shaft by means of the adjustable link and lever, by depressing the roller which travels over the cam in the controller wheel; at the same time, one shipper fork is moved by the connecting rod at its upper end, which is pivoted near the upper rim of the controller wheel, far enough to cause one of the clutches to engage its other part on the sleeve attachment to the bevel gear, so as to drive the worm shaft and rotate the cable drum. At the same time, the connecting-rod attachment to the shipper fork opposite moves across the centre of the controller wheel without producing more than enough movement to take up the lost motion in the clutch parts to which it is attached. Pulling the hand rope in the opposite direction brings the parts back to their original position, disengages the clutch, and sets the brake on the worm shaft. Pulling still further in this direction, the opposite connecting rod travels so as to move the shipper forks, and engages its clutch, turning the hoisting drum in the opposite direction, while the first-mentioned connecting rod moves across the center without causing any appreciable movement of the shipper fork.

The motor runs continuously in one direction during working hours, and there is no heavy rush of current in starting as with a direct current series motor, with its tendency to drop the brilliancy of the incandescent lights on the same circuit. Neither is there any necessity for complicated automatic starting rheostats, safety devices, and multiplicity of connections; only two wires connect the secondary of the transformer, which furnishes the alternating current to the motor.

There are many classes of work in connection with which perfect uniformity of speed is of vital importance. To such cases these motors are peculiarly adapted, as an overload of fifty per cent may be instantly thrown on to these motors, and the next instant thrown off, without changing the speed in the least; not even causing a variation of a fraction of a revolution.

These motors are suited to any frequency in general use in this country, and are wound for from 140 to sixty complete periods per second, the speed being fixed by the frequency of the generator or circuit to which it is connected. It will no doubt be understood, however, that a motor wound for 140 periods, or 16,800 alternations, under which conditions it would run at 1,400 revolutions per minute, would not be suited for use on a sixty-period circuit, or 7,200 alternations, where the motor would run at 600 revolutions per minute.

All sizes, from one horse-power up to and including the ten horse-power, are wound for one hundred to 110-volt secondaries, though the larger sizes are designed for higher potentials, as 200 and 300 volts, and even for direct connection to primaries where proper attendants are in charge; though this would not be safe in general practice, where the person dealing with the motor is not fully acquainted with what he is handling.

While this motor was designed for single-phase circuits, yet it is obvious that it will work quite as satisfactorily when connected to either leg of a two or three-phase circuit; and where such circuits are loaded with induction motors, a few synchronous motors properly distributed and somewhat over-excited would serve to allay the pernicious effects of the inherent lag or idle current that goes with induction motors, at the same time raising the electric motor force at the extremities of the line, reducing the drop in the conductors and allowing the generators to do more work, inasmuch as they would not be required to deliver so large a wattless current.

This synchronous motor is also a good rotary transformer, and lends itself very conveniently for charging storage batteries and electrolytic work; the alternating current entering at collector rings, while direct currents are delivered from the commutator brushes. For laboratory work, and as a piece of apparatus in colleges that teach electric engineering, it is invaluable; for, besides the previously mentioned uses, it may be driven by direct currents as a series motor; further, it may be run at a constant speed as a direct current shunt motor, while from the collector rings alternating currents may be taken at any frequency, dependent upon the speed, which can be regulated by resistance in the field or armature circuits; or, belt-driven, it may be used as a self-exciting alternator.

DISCUSSION.

THE PRESIDENT: Gentlemen, the paper just read by Mr. Leonard is now open for discussion.

MR. WAGNER: Mr. President, I should like to ask Mr. Leonard the effect on the operation of the motor, when running at full speed, of switching at the central station. I have had such motors in operation myself, covering a period of three years, and I find that it is an almost insurmountable objection to the use of the synchronous motor, as the frequent switching found necessary to properly divide the load on alternating current generators, causes the motors to fall out of step. I should like to know if he has covered that point.

Mr. Leonard: What Mr. Wagner says is quite true. If a motor fully loaded has the current switched off, it will slow down to a point so much below synchronism that it is impossible to go on unless the switch is reversed so as to put it in the position of starting. In most stations where these motors have been used, the circuits on which the motors run are not switched, except at hours when the motors are not in service; or it is done while the machines are in multiple, preventing the breaking of the circuit and the cutting off of the current. No harm occurs to the motor, however, as its self-induction prevents abnormal flow of current.

Mr. Van Trump: I should like to ask Mr. Leonard if there is not a difficulty in operating these motors, due to a difference in the curve; that is, in the wave line of the motor differing from that of the generator? I have operated synchronous motors to some extent, and I find there is considerable difficulty in getting any motor to work in this way, due to the difference in the character of the curve making a fluctuation.

Mr. Leonard: These motors, Mr. President, are wound, as stated in the paper, with a concentrated winding; that is, what is known as the ironclad winding in alternating circuit phraseology; and, while they operate with a greater torque, that is the ultimate point at which they will fall out of step. The utmost load they will carry with an ironclad armature is about fifteen per cent—ten to fifteen per cent—greater with an ironclad armature than with a smooth core winding. Most of the single-phase alternators in general use now, however, are wound with the ironclad winding, and the only difference that would occur would be that the maximum torque—the limit of the load—would be a little lower with a smooth core winding than with an ironclad. The wave line makes little difference.

MR. FERGUSON: Mr. President, I should like to ask the gentleman a question. I wish to know if there is not a danger, in case that machine were started up on a light load and the operator did not fix the switch in time, of allowing the machine to accelerate its speed to such an extent that it would go all to pieces.

MR. LEONARD: That would happen if it were allowed to be carried on to a sufficient extent. The instructions going with the motor state that the switch should be reversed the moment the lamp is on top of the switch, directly in front of the man whose hand is on the handle. Just the moment he sees that light, his instructions are to reverse the switch. If he fails to do that, and there is no load on, the acceleration of speed might go on, as Mr. Ferguson suggests, to an extent sufficient to throw the armature windings out and injure them. We have had very few cases of that kind, however. The thing has occurred, and it might occur with a careless hand. But if a man does it once, he never does it again. (Laughter.)

MR. WAGNER: Mr. President, I should like to refer again for a moment to the question of central station switching. It is found necessary to divide the load between a great number of generators at certain times of the year, quite early in the afternoon, long before the motor is taken off; in other words, at a time of the year when the day and night loads overlap; and it seems hardly possible to delay such switching to such times of the day—say after six o'clock—when the motors are generally not in operation. Mr. Leonard admits that the motor must stop if any such switching occurs at the station. His reference to stations where generators run in multiple applies to plants that are very recently installed or in process of installation. Until the last few months, I might say, there has been practically no place in the country where generators were operated in multiple. We are anxious for a motor that will operate on existing stations and under existing methods, and it seems to me that he fails to bring out very clearly the point of how such stoppages of the motor service are to be prevented.

MR. LEONARD: In practice, we have not found very much objection on account of the feature mentioned by Mr. Wagner. Of course, if circuits are switched when the motor is loaded, and the phases are not exactly coincident in both generators—which is hardly likely to be the case—the motor will fall out of step; but it seems to me that it might readily be arranged so that feeders supplying the motor-power could be handled in such a manner that it would be unnecessary to switch very much during the hours of the motor load. In the little experience that we have had, we have found that point no great objection. In some cases it has been necessary to switch; but the attendants at the central station generally know which circuits the motors are on, and they endeavor in most cases to avoid switching the motor circuit. It is an easy matter, however, in case the motor is thrown out of step, by cutting off the current a few seconds, to start the motor again, as it takes only a few seconds; and as there is a great demand for these motors, people are willing to put up with that slight objection, or to adjust their conditions so as to avoid this difficulty. At least, that is what we have found.

MR. WAGNER: I wish to say, Mr. President, that I do not make these criticisms as reflecting at all upon Mr. Leonard's motor, but merely from the fact that I have had motors of exactly the same type in operation for the last three years, and have finally decided that I should have to give up work in that line, as such objections seem to be insurmountable in ordinary practice. I admit that I have failed to solve the problem myself.

The President: The next order of business is the reading of a paper by Mr. A. Churchward, on equalizer systems of distribution.

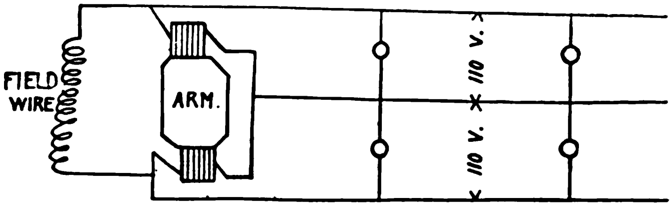
EQUALIZER SYSTEMS OF DISTRIBUTION

In preparing the following paper, the limited scope of which is indicated by its title, I have assumed that a three-wire system is supposed to be the only safe and reliable system of direct current distribution for motors and lights in our cities.

It is my intention to refer to the many methods that have been devised to accomplish the results obtained by the three-wire system, without the use of a divided source of electrical energy and a compensating conductor connected to the point of division.

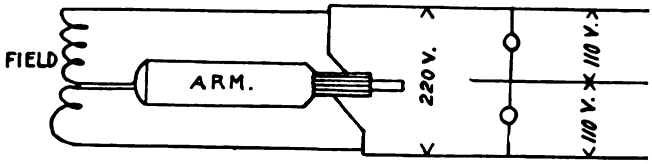
I now lay before you an abbreviated list of such methods:

1. Using a single dynamo with two commutators. Very little would be gained by this, even if it did not infringe the above system, as one commutator on a large machine is all most people can put up with.

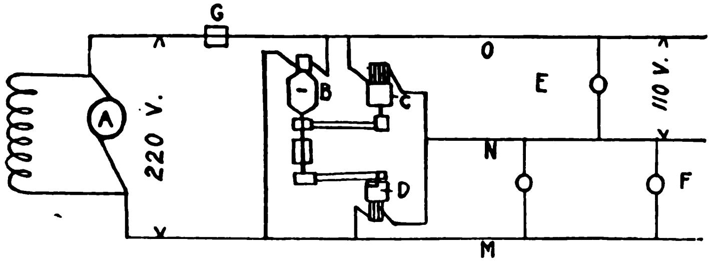


2. I do not think that at this late day anyone is

likely to try the combination of a 220-volt dynamo and two sets of lamps connected in series by a third wire.



3. This time, we come to a true system of equalizer distribution. We have only one generator of, say, 220 volts—A; and two small machines C and D, capable of taking care of the unbalance due to turning off lights on either side of the circuit; and a motor B, connected to the two outside mains and driving the two machines C and D.



In this system, our comparative loss is quite great at light loads, as we have a constant loss due to the friction, field current, eddy, and foucault currents of three machines. Another disadvantage is the difficulty in keeping the system properly balanced, owing to drop in speed of motor with increase of load, drop in voltage of one of the machines C or D when running as a dynamo (due to armature reaction and C-R losses in the armatures); and, on the other hand, the load being taken off, the voltage will be raised on the lightly loaded side.

The action that takes place is this, and will be found nearly the same in all equalizer systems.

When both sides of the circuits E and F are equally balanced, the motor B runs free, only taking enough current to keep C and D up to the proper electromotive force. Should the load be changed, however, so that F had twenty amperes and E ten, then there would be unbalance of ten amperes.

An ammeter placed in the circuit at G would indicate fifteen amperes as the amount of current to run the combination B, C and D.

Fifteen amperes would flow from the main (F), M to N, and the machine D would not act as a dynamo and supply the other five amperes.

On the other hand, the machine C would take the five amperes from the neutral N, and run as a motor, helping to drive the motor B.

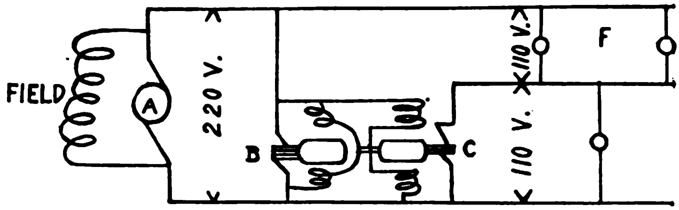
Thus it can be seen that under ordinary conditions we can dispense with the motor B, and couple C and D together, as per diagram.

But, by using the motor B, a greater load on one side can be taken care of.

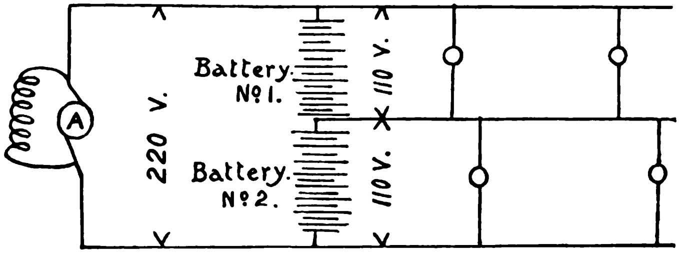
4. A single dynamo, 220 volts, A, and a small machine of 110 volts, C, driven by a motor B connected across the 220-volt mains.

The motor B drives the machine C so that the pressure across E and F are equal; should the load be increased on E, the pressure will fall, and the machine C will supply the extra current needed to balance the pressure; if the load on E is less than on F, then C will run as a motor, driving B as a dynamo.

In this case, also, there will be a slight unbalance of pressure, due to armature reaction, etc.



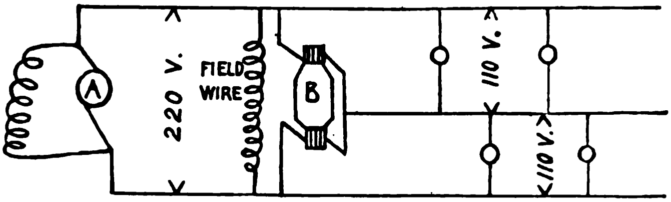
5. Still another method has been proposed. This employs a single dynamo of 220 volts. To the brushes of this machine are connected the two outside wires; the neutral wire is connected to the centre of the armature coils, and this raises a potential midway between the two outside wires.



6. A system in use in central stations in Europe might be mentioned here, but we can hardly call it an equalizer system. It consists of a 220-volt dynamo and two sets of batteries. The accumulators here play the same part as their namesakes do in a system of hydraulic supply.

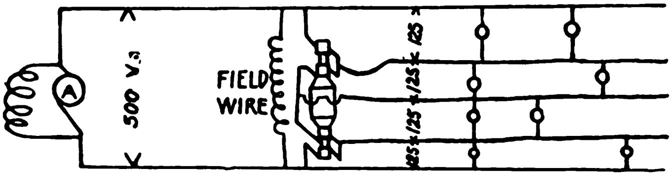
The battery connected to the circuit that requires most current, discharges into the circuit, and thus helps the dynamo; and the battery in which the demand is smaller, is charged by the surplus current.

There is no economy in an installation by this method over others, the accumulation costing much more than a rotary equalizer.



We gain this, however; during the hours of light load, the batteries may supply all the current required, permitting the shutting down of the central station during those hours.

7. I intend now to bring to your notice an equalizer that has passed the experimental stage, and has been in operation day and night for two and one-half years; no lamps have ever been lost owing to lack of balance of the system.



Again, we only require one generator, A, 220 volts, and one small machine with two commutators, B;

We have only two bearings to worry about;

Only one field loss;

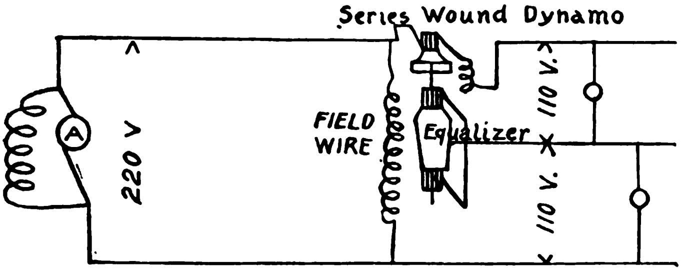
One loss due to hysteresis and eddy currents,

And absolutely no armature reaction.

There being no armature reaction, there will be no drop in speed, no sparking at the brushes with a change of load, and the capacity of the equalizer will be the heat limit of the armature winding.

By using the equalizer system, we have one unit, or set of units, running at a high efficiency, and for a reserve we have only one machine.

It is not limited to only 220 volts. Where a company has a motor trade much scattered, they can take, for instance, 500 volts, and run a good distance with economy, then put an equalizer in a central location, and supply their customers with lights at 110 to 125 volts.



Or, again, we want light and power in one unit.

We can take one generator, fifty kilowatts, 250 volts, and a motor of fifty horse-power, but with two commutators; or, in other words, on a fifty-horse-power equalizer, we can take either the full load in power off the pulley, or the full number of lights off one side at 110 to 125 volts, or in any proportion we see fit.

Still another advantage of this system: we can always compensate for the drop in our line at any point, independent of all others.

This we might call a booster equalizer system.

When the heaviest loads are on our system, and the sides balanced, all the equalizer does is to run free as a motor. Now, by attaching a small series wound dynamo to the end of the shaft of the equalizer, and adjusting it to the load and drop, we shall first boost our pressure and then equalize it; so that, given a district with various points of distribution and various drops, we can run over the longest and heaviest loaded circuit at the same pressure as our station electromotive force.

DISCUSSION

THE PRESIDENT: Gentlemen, if anyone desires to make any remarks on this paper, they are now in order.

MR. C. L. EDGAR: Mr. President, it seems to me that these systems, in general, all have one weakness, depending upon one inherent difficulty. Every one of these systems, as I understand it, will go to pieces if you get the neutral wire against the outside wire. Am I right in this? If the neutral wire gets on the outside wire, aren't you going to burst all the lamps on the outside?

MR. CHURCHWARD: No, sir.

MR. EDGAR: Let me assume a case. Supposing you have the maximum capacity on your generator; that generator is going to sustain 220 volts between the outside wires without question.

MR. CHURCHWARD: Yes.

MR. EDGAR: Then do you claim that your equalizer is going to sustain the entire capacity of that generator?

Mr. Churchward: Yes, sir.

Mr. Edgar: Assuming that you are running at full capacity?

Mr. Churchward: If you are running your generator at full capacity with the circuit, the equalizer will not be affected, and it will take very little more current to show the trouble.

Mr. Edgar: We do not find that to be true in the three-wire system; we simply keep on going until something burns off.

Mr. Churchward: I know that very well; I've seen that. I was told, I think, by the company that you represent, that I was putting a millstone around my neck, two and a half years ago. It has not dragged me down yet.

Mr. Edgar: I never heard of it. But that has been a great drawback in all the systems. But it seems to me that your equalizer has to have an ampere capacity equivalent to the total ampere capacity of your station.

Mr. Churchward: No; because we wind the equalizer with a large wire.

Mr. Edgar: It has to have balance and everything equal to the total capacity of your station.

Mr. Churchward: A very small wire will stand a tremendous current.

Mr. Edgar: You are going to have an equalizer that will stand an overload?

Mr. Churchward: They will stand an overload. The point is this—to get around the three-wire system. I put it at the beginning that it was the object to get around the standard three-wire system. I was not putting that as equal to the three-wire system.

Mr. Edgar: We tried that same experiment three or four years ago, when it was comparatively new. Of course, we got into a circus at once; and I have never seen a scheme of the kind that did not get us into the same trouble.

Mr. Churchward: The same point you speak of was brought up at the time I was starting this, and we have been looking for it ever since.

Mr. Edgar: It seems to me that you are practically putting as much money into your dynamo as if you had the three-wire system.

Mr. Churchward: I quite agree with you. Of course, if the output of the station is one hundred kilowatts, then one hundred kilowatts will be the capacity of machines in either case.

Mr. Edgar: I thought your principal point was that on your equalizers you were going to be able to put in very small machines, comparatively.

Mr. Churchward: No; that is not the point.

Mr. Ferguson: I should like to ask Mr. Churchward a question. As I understand it, he proposes to have these small equalizers scattered all around town.

Mr. Churchward: In each large block.

Mr. Ferguson: Not in the central station?

Mr. Churchward: No.

Mr. Ferguson: Then you do not contend that it begins to compare in point of economy with the Edison three-wire system?

Mr. Churchward: No, sir; I do not. I say that the system is put there as a method of getting around the three-wire system.

Mr. Ferguson: Irrespective of economy?

Mr. Churchward: Irrespective of economy. The idea of my paper was not to put forth some new idea of system for modern central station practice, but rather to help out those stations that already have their plants and charters. Also for factory and mill work, the economy and interchangeability of this system is in every way equal to the standard three-wire. Again, in certain cities, companies have to pay $1,000 per mile per year rental. By using the equalizer system, two circuits of two wires can be run where only one circuit of three wires can be. The rental of conduits saved will more than pay for the equalizers and cost of running same; so that, although the economy may be slightly under the standard three wires, the net receipts will be higher.

Upon motion, the convention went into executive session.

MR. ARMSTRONG: Being now in executive session, I move that we adjourn until after the close of to-morrow morning's meeting.

Carried.

RÖNTGEN RAYS.

SPECIAL EVENING SESSION.

LECTURE BY MAX OSTERBERG, E.E., A.M., Fellow of Columbia University.

Mr. President, Ladies and Gentlemen :

"And here I am at last,
With useless knowledge curst,
No wiser than at first."

These words of Göthe are very forcibly brought to my mind as I stand here to review the work of Röntgen ; for, in spite of the intense interest taken by everyone whose previous training or accidental opportunity has allowed him to experiment in this direction, we have not more than lifted one foot in the march of progress; the first step has hardly been completed. The general public, whose varied interests do not allow it to carefully study these phenomena, has been completely swamped with newspaper reports, whose only real value consisted in imbuing the reader with the fact that something has been accomplished which deserves careful study, and which may be applicable to the sciences; especially to the study of what has thus far been classed as the invisible. I consider it a great privilege to belong to that profession whose work is most closely connected with this newly discovered phenomenon. It is a connecting link between the exactness of natural philosophy and the invaluable study of human anatomy; and if the physicist can assist the medical profession in relieving the pains of the distressed, and thus, if not prolong the life, at least make the days of our fellow men a happier existence, we may justly feel that our own life is worth living and that our labors carry with them their own reward.

In trying to elucidate Röntgen's discovery, we are confronted with the difficult task of starting with the most intricate developments of the science; and, in order to free you from this almost natural feeling of listening to some peculiar freak of nature, which seems to stand alone like a refreshing well in the middle of a desert, you must allow me to commence with some historical remarks; an opportunity that I gladly seize, since I may thus pay tribute to the noble minds that have preceded our latest scientific hero.

Michael Faraday, a man whose work is being thoroughly appreciated, but whose influence has not as yet reached its limit, forms, as usual, the starting-point in tracing the history of Röntgen's discovery. Of him, his worthy follower said: "We regard Faraday as at once the most noble and most useful type of a scientific man. The nation is bigger and stronger in that Faraday has lived, and the nation would be bigger and stronger still were there more Faradays among us." Faraday had a deep insight into the nature of the phenomena that he observed. The symbols of mathematics were not at his disposal, but he possessed the power of picturing his ideas with such an exactness that it only took a mathematician to give them the form that is considered necessary in our days to allow a man to rank as a scientist. In his "Experimental Researches," as far back as 1838, he made a statement that would be worthy of the noblest mind to-day, even in the light of all the knowledge and experience gained during the past fifty-eight years. Permit me to read this section in our master's own words :

"The action or effort which may be expressed by the general term discharge, may take place, as far as we are aware at the present time, in several modes. Thus, that which is called simply conduction involves no chemical action, and apparently no displacement of the particles concerned; a second mode may be called electrolytic discharge; in it chemical action does occur, and particles must to a certain degree be displaced; a third mode, namely, that by sparks or brushes, may, because of its violent displacement of the dielectric in its course, be called a disruptive discharge; and a fourth may, perhaps, be conveniently distinguished for a time by the words convection or carrying discharge, being that in which discharge is effected either by the carrying power of solid particles or those of gases and liquids. Hereafter, perhaps all these modes may appear as the result of one common principle, but at present they must be considered apart."

Faraday's eminent successor, James Clerk Maxwell, who clothed Faraday's language in mathematical terms, succeeded in ascribing three of these manifestations to one cause, namely, to a peculiar state into which the ether—that subtle substance which pervades all space—may be put. To the technical mind, this idea is contained in Maxwell's displacement currents. In consequence of Professor Röntgen's discovery, it may now be possible to add the fourth manifestation that Faraday mentioned to the same category.

Faraday had explicit confidence in his theories. Once, when expressing his regret at not being a mathematician, he added that if some day a mathematician should read his theories, he would undoubtedly be able to prove them mathematically. James Clerk Maxwell, also a Briton by birth, while yet a young and enthusiastic student, read Faraday's "Experimental Researches." The clear, precise wording seemed to reveal to him such mathematically logical consequences, so clear and comprehensive to his mind, that he set about to prove the correctness of the new theory by mathematics. His methods differed from those of Faraday. The latter saw a fact, which he then took apart to explain the minutest details; while Maxwell, on the other hand, started with the details, logically weaving them together to form a whole. But then the unexpected happened. The newly risen and so portentous movement came to a standstill. The road upward seemed barred. Maxwell's mathematics were not understood. Years went by. Maxwell, unfortunately, died too young to write a commentary to his own work. It was not difficult to recognize the means to pursue in order to shed a possible light on the subject; what was wanted was an experimental proof. The difficulty in our case was that almost as great a mind was required to furnish the experiments that were to establish the truth of the theory. This brilliant task was accomplished twenty-five years later, by Heinrich Rudolf Hertz. But the work of Hertz extended in a still different direction. He was not only a scholar, not only an experimentalist, but he was also a master in teaching; a man so full of sincerity, so full of modesty and inspiration, that ever so many young, active men took his advice and suggestions, and, helped by his knowledge and inspiration, they, too, became creative; and thus, like healthy seed, his good influence scattered over several centuries, and has interested such men as Lenard and Röntgen in the fruitful line of research that he was pursuing up to the sad time of his death.

We have now traced the line of scientists whose names are so honorably connected with the scientific development of our century. Before taking up the work proper, we must call attention to several not less worthy members of the scientific profession, who, on account of the intricate nature of their researches, could not subject them to mathematical analysis. They are researches of which Maxwell says that, "they are exceedingly important, and when they are better understood they will probably throw great light on the nature of electricity, as well as on the nature of the gases and of the *medium pervading space*." I am referring to vacuum tubes, or Hittorf and Crookes tubes in particular. These are the outcome of the Geissler tube, and the Geissler tube, again, is the result of experiments made over one hundred years ago. A Geissler tube is simply a glass tube containing rarefied air, or any other gas; usually prepared in fancy shapes, and often surrounded with different fluids possessing fluorescent or phosphorescent properties. Two metallic inlets—made preferably of platinum, since the latter has the same coefficient of expansion as glass—convey the electric current from an induction coil, and produce brilliant effects.

If we now continue to exhaust our tubes, we find that as soon as a high vacuum is obtained, those properties are created that at present demand our attention.

William Crookes, in a lecture on radiant matter, delivered before the British Association at Sheffield, August 22, 1879, propounded a new theory, in which he announced to have discovered a fourth state of matter, thus dividing matter into solids, liquids, gases, and "radiant matter." He claimed to have observed that state only in very high vacua, and he succeeded in exhausting a tube so that the air inside corresponded to a pressure of about the hundredth of an inch in a barometric column three miles high. It is not necessary at this stage to go into a discussion of this fourth state, and, since it may easily meet with objections, it might be as well for our purpose to simply say that some peculiar properties manifest themselves when we work with very high vacua, one of the principal phenomena being that the cathode or negative pole is the one that presents peculiarities; it appears to become the more important of the two poles, and exhibits properties that are entirely distinct from those under ordinary conditions. Instead of saying that we are dealing with radiant matter, let us assume that we are simply dealing with rays that are generated at the cathode, and are therefore called *cathode rays.*

These cathode rays exhibit very remarkable properties; for example, they leave the cathode in straight lines, and normally to the surface, at any point of the cathode, and entirely independent of the position and surface of the anode. They produce very strong phosphorescence of the glass wherever they strike it, while the luminosity produced is but slight. They are deflected by a magnet, and assume, in that case, the shape of a parabola similar to the flight of a cannon ball under the influence of gravity. The cathode itself becomes very hot, and if it has the shape of a concave mirror, the concentrated rays will develop heat in their focus. Cunnington, in England, succeeded in melting glass in this way, and Crookes could even melt platinum. After a long time of discharge, the inside walls of the globe or tube are covered with the material of the cathode, from which it follows that the rays carry material particles; but that does not, by any means, prove that the rays are due to material particles. These material particles are carried off because the cathode becomes sufficiently hot to cause volatilization.

All these points were verified years ago, and when Hertz commenced to work with vacuum tubes, he was well aware of these properties. He added a valuable suggestion to the work, which Philippe Lenard—now professor at Breslau, but at that time *privat docent* at Bonn—carried out in a most conscientious and admirable manner. Hertz found that very thin filaments of gold leaf were transparent to cathode rays, for he succeeded in making glass phosphoresce when separated from the cathode by means of a gold leaf. Lenard then made the next step. He suggested investigating whether phosphorescence could possibly be observed outside of the glass tube, and for that reason he sealed a piece of aluminum to one terminal of a glass cylinder, forming what he called an aluminum window. He actually observed phosphorescence outside of the aluminum window, but he could affect a plate only through a distance of six centimetres. He was positive that he had nothing but cathode rays, for he could deflect them by a magnet, just as he could those inside of the glass tube. If he rarefied the air outside of the aluminum window, he could easily increase the distance through which phosphorescent plates could be affected. Lenard made use of this observation to draw the very interesting conclusion that the cathode ray is not due to radiant matter, or Crookes' fourth state, but that it is a property of the ether; a view that had been held by several German physicists, without the support, however, of any experiments. Lenard did a great deal more and valuable work. He determined, for example, that the absorption of the rays that he observed were proportional to the density through which they were passing; he showed that by compressing hydrogen until it had the same density as oxygen, the absorption of both would be the same; but—and here comes one of the most essential points to be considered—he was not aware that he had any other but cathode rays. I actually regret to be forced to make this statement; but in these times, when scientists make it their greatest aim to achieve privileges of priority, they must also be willing to accept reproach for work that does not directly help to advance.

Lenard's position with respect to Röntgen's is about the same that Galvani's was with respect to Volta's. Although we admit that Galvani had started the work, we must also admit that it might have slumbered for years and years had it not been for Volta, for the simple and only reason that Galvani ascribed his phenomena to a wrong cause. Lenard mistook the rays that he observed for cathode rays, pure and simple; but he was not aware of this new ray, with new properties, and possibly with a key to the most obscure chambers of science.

Thus we have arrived at the essential point of the paper—at the question: What are the Röntgen rays? I may be pardoned for not using the term X ray, the word used by Professor Röntgen in his now celebrated lecture; but he availed himself of this term only to distinguish it from the light rays about which he spoke, and probably, also, to allude to the undetermined nature of the same. To make an attempt to explain the nature of the Röntgen ray, and

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then to state its manner of manifestation, would be working against the natural law of historical development, which I have tried to follow up to the present time. We will therefore take up its characteristics.

In order to present the subject to you in as clear a manner as possible, let us compare the properties of the Röntgen ray, whenever possible, with the cathode and Lenard rays; for then, whenever a new feature is introduced, we can more intelligently appreciate it. Any highly exhausted tube, through which the electrical charge takes place, may be covered with a piece of black paper or thin cardboard, and it will be observed, in a perfectly dark room, that a fluorescent screen—that is, any surface that has been coated or washed with barium platino cyanide, for example—will light up brilliantly, and fluoresce equally well, whether the treated side or the other be turned towards the apparatus. This fluorescence is observable through a distance of two metres. Thus we have a phenomenon here which shows that phosphorescence can be observed through one piece of glass, that glass, however, being the surface of the Crookes tube, and one or two pieces of cardboard. Lenard found fluorescence only in the direction of the aluminum window; Röntgen observed his effect for a distance of two metres; Lenard only through a distance of six centimetres.

Professor Röntgen tried to deflect the new rays by means of a magnet, as Lenard deflected the cathode rays, but he found it impossible to do so. This introduces an essentially new property—one of the utmost importance.

An attempt to deflect the cathode rays in the tube that produced the phosphorescence on the surface of the glass, showed that in this case the direction of the Röntgen ray would be changed; but only inasmuch as it went forth in straight lines from the spot in which the cathode rays were concentrated. This led Professor Röntgen to the conclusion that the new ray was generated on the surface of the glass by the cathode; but shortly afterward he found that an aluminum cylinder, excited by means of the discharge apparatus, would also excite the Röntgen ray. This would lead one to the conclusion that there are no Röntgen rays inside of a Crookes tube, and Professor J. J. Thomson, in England, made an experiment to prove the correctness of this assertion, which was generally accepted, not only as extremely ingenious, but also as conclusive. To this, however, I cannot agree. Ingenious as it appears, it has no practical value, for the negative result which it obtains is not by any means a proof of the non-existence of the rays inside of a vacuum.

Professor Oliver J. Lodge, in a contribution to the London *Electrician*, February 7th, 1896, wrote: "J. J. Thomson has exposed a protected plate in the very rays themselves, inside the vacuum, and got no result. It looks as if the streaming particles alone could not achieve it." It appears that Professors Thomson and Lodge, and, in fact, a great many others, are not aware of the fact that a highly sensitized plate may cease to respond to the influence of light when inside of a vacuum. In order to act photographically on a sensitized plate, it takes, if Crookes' third element theory is sound, a certain amount of moisture; extremely little, to be sure—as little only as will be in the atmosphere at any time, even in the very driest condition—but more than in as perfect a vacuum as is required to generate the Röntgen rays. Now, if a sensitized plate is not even fogged by light, it may well be possible that the Röntgen ray develops no actinic effect.

The following statement, which may be of some value in this connection, is taken from the *Photographic Annual*, of 1893: "Carefully dried silver chloride does not darken when exposed to light in a vacuum, even in the presence of mercury vapor; neither does it darken when exposed in an atmosphere of carefully dried oxygen."—H. B. Baker, C. S.

Various other experiments, the details of which need not now be enumerated, led to the conclusion that the transparency of different substances of the same thickness is mainly conditioned by the density; a result similar to the one found by Lenard with his rays. A very carefully carried out experiment, however, showed that density is *not* alone in its influence; for glass, aluminum, calcspar and quartz all have about the same density, while their transparency for the Röntgen rays varies widely.

Röntgen rays are found to travel in straight lines. Professor Röntgen has observed but a very small amount of reflection, and for several weeks it was generally claimed that there was no reflection. It is quite certain, however, that the rays cannot as yet be refracted; thus, they cannot be focused like light rays, and hence any picture that is made on a sensitized plate will not be a photograph in the true sense of the word, which means the fixing of a real image, but it will simply be a shadow picture. For this I have, on various occasions, used the word skotograph, and still wish to adhere to it, since all other words thus far proposed have, in my opinion, more disadvantages than this nomenclature. Thus it happens that the bones of the human hand can be plainly shown, since the flesh is more transparent to Röntgen rays than the bones; but, by overexposing a plate, you can make the bones disappear, too, and if any solid substance harder or denser is inside of the bone, it will then be easily discovered. Dr. Pupin has demonstrated this very conclusively in several skotographs.

Another discovery recorded by Professor Röntgen is of great interest, for several investigators, American and English, apparently discovered it independently, but, at any rate, later than Professor Röntgen.

Röntgen said: "If the hand is held between the discharge tube and the screen, the dark shadow of the bones is *visible* within the slightly dark shadow of the hand." This is a very short but precise statement, and since, in the beginning of this paper, Professor Röntgen spoke of working in a dark room, with black cardboard over his tubes, his process is completely defined. If he can thus see bones through the hand on the fluorescent screen, there is no reason why he should not see the movement of joints. Mr. E. P. Thompson, of this city, has published a very ingenious and interesting device for doing the same thing, and called it a kineto-skotoscope; and Professor E. Salvioni, in a communication made to the Medico-Chirurgical Academy of Perugia, on February 6, 1896, has described a similar arrangement, which he called cryptoscope. Although the respective boxes and arrangements of both these gentlemen may be new, the discovery itself belongs again to no one but Professor Röntgen. Mr. Edison has probably brought this arrangement to a higher degree of perfection than anybody else, by finding a fluorescent substance whose fluorescing property is six times as good as barium platinum cyanide, the substance used by Röntgen.

Now it remains to discuss the various experiments made by others than Professor Röntgen since the announcement of the discovery, and to investigate in what way different methods have been introduced. It is not advisable to pay too much attention to the work reported in the daily papers, which, although it may be correct, lacks the guarantee of exactness that the recognized technical journals give it. In the first place, we must consider the method of generating the Crookes tube discharges. In his lecture, Professor Röntgen mentions the use of a Ruhmkorff coil; this simple device alone, however, will not, according to various experimenters, produce the best effects, and, in fact, Professor Röntgen himself mentions in his second paper that he has used a Tesla condenser and transformer.

The frictional machine has been used with considerable success by many experimenters, notably, Dr. William J. Morton; the ordinary induction coil, with rapid makes and breaks, or, in fact, any device that generates rapidly intermittent high potential currents, might be used.

Dr. Pupin's device of putting a brake on a motor, and taking up the spark by careful adjustment by means of condensers, tends to give extremely sharp and distinct pictures.

The sensitized plate is still capable of improvement, but it has thus far been found by several experimenters that a slow or landscape plate takes the pictures in a shorter time than an instantaneous one.

The principal success achieved by others than Professor Röntgen, consists mainly in perfecting the pictures taken, in shortening the time of exposure, and in producing a more perfect fluorescent screen. The latter, which I have mentioned before, is Mr.

Edison's, who, by discovering the fluorescent properties of tungstate of calcium, added another valuable gem to his crown of glory. To shorten the time of exposure, Dr. Pupin has suggested a method, which is being universally adopted, and that is, to put a fine layer of fluorescent material over the sensitive filament. The Röntgen radiance is thus transformed into light, and the difference in density is thus intensified.

I have touched but slightly on deflection and reflection experiments; but I will come back to them once more, on account of the importance attached to them.

It is by such properties that we draw conclusions as to the nature of the Röntgen rays. You remember, perhaps, that Professor Röntgen, in his original paper, suggested the possibility of having discovered *longitudinal* or condensational waves; that is, the kind of wave with which sound is propagated. This theory, although not as yet disproved or confirmed, has been practically abandoned; and since reflection has been observed, the theory of transverse waves—the kind of wave that is to be observed when we make a string vibrate—has again been taken up. Without going into details of the why and wherefore, I will simply say that if we are dealing with those waves, they must be waves of very short wave length; considerably below the violet part of the spectrum. The outer particles of a perfectly polished metallic mirror must be a considerable distance apart in comparison to the length of one wave. This is shown by the fact that deflection of the Röntgen radiance is greater from a piece of wood, or from the hand, than from a finely polished surface.

A third theory, which as yet shows no improbabilities, is one suggested by Dr. Pupin, and based on a paper by Helmholtz, written during the last year of his life, according to which a circular motion of the ether is possible.

These things, however, bring us into deep water, and I dare say that, in presenting these difficulties, I tend to discourage more than to inspire; and that is the one fault of which I do not like to be guilty, for we stand before a period—or, perhaps, we are right in the midst of it—when every thinking mind should feel that ours should be a period of progress; that before this century closes, some of the secrets of nature will reveal themselves to us, and then we shall go on and on. For, as Tennyson said:

"Not in vain the distance beacons. Forward, forward let us range.
Let the great world spin forever down the ringing grooves of change."

ORDER OF BUSINESS

WEDNESDAY, May 6th

THIRD SESSION, 10.30 A. M.

1. Paper—" Distribution of Light and Power by Alternating Currents." By W. L. R. EMMET.

FOURTH SESSION, 2.30 P. M.

1. Paper—" Evolution of Interior Conduits from the Electrical Standpoint." By LUTHER STIERINGER, M. I. E. E.
2. Paper—" Some Account of the Evolution of the Inductor Alternator." By JOHN F. KELLY.
3. REPORT. Committee on Standard Rules for Electrical Construction and Operation. W. J. HAMMER, Chairman.
4. Topic—" Standard of Candle-Power for Incandescent Lamps."

THIRD SESSION

The president called the meeting to order at 10.30, and announced the first business to be the reading of a paper by Mr. W. L. R. Emmet, on results accomplished in distribution of light and power by alternating currents.

RESULTS ACCOMPLISHED IN DISTRIBUTION OF LIGHT AND POWER BY ALTERNATING CURRENTS

The introduction of successful polyphase motors has constituted a very radical and important step in the development of the electrical art. The number of persons who realize the importance of this step is as yet small, and, like other new things, it cannot attain great successes until its merits and possibilites become more or less familiar to the public and to the practical business men on whom the responsibilities for new developments must largely rest.

In the past, the use of alternating currents has been almost exclusively for incandescent lighting, and this narrow limitation has crippled the development of the art. While the applications of direct currents have called forth very large investments in plants and distributing systems, the uses of the alternating current have, as a rule, been on a much smaller scale, and the methods used have been developed rather with a view to reduction in first cost than to the attainment of the most economical results in operation.

The reasons for this somewhat half-hearted development may be stated as follows:

First—The average efficiencies attained in most alternating plants have been very low.

Second—The distribution of potential obtainable with the ordinary methods has been imperfect.

Third—No reliable alternating arc lamps have been available.

Fourth—No practicable form of single-phase alternating current motor has, up to the present time, been introduced.

At no time have all these difficulties been entirely unavoidable in alternating current distribution; they have, however, been fixed features of the system as it has in the past been installed by our manufacturing companies and used by electric light companies in this country; the state of the art being such that improvements were beyond the reach of most central station managers.

In recent years, great developments have been in progress in the branches of electrical science pertaining to alternating currents; much new apparatus has been developed, plants have been installed on new lines, and practical results are to-day being accomplished that show that it is possible to overcome all the objections that have been mentioned.

We will briefly review in order some of the means by which the difficulties mentioned have been and can be avoided.

EFFICIENCY

The greatest losses in the average alternating plant are due to the waste in iron cores of transformers, which goes on whether the transformers are loaded or not. This waste can be reduced, either by the use of transformers of high light load efficiency, or by arrangements for cutting out transformers at light load.

Where primary distribution is used with large numbers of independent transformers, the extent to which these remedies can be adopted is very limited, since reduction of core loss can be obtained only at the expense either of regulation or of first cost.

If, however, secondary distribution is used—that is, low-tension mains with transformer sub-stations—it is often possible to arrange means of cutting out transformers at times of light loads.

Furthermore, on such systems, very accurate regulation in transformers is a matter of no importance, since all transformers divide the load more or less evenly between them, instead of operating from the same line at various conditions of load as in primary distribution. Thus, for this secondary work, we can build special transformers having very small core losses, and thus obtain very high all-day efficiency without impairment of regulation.

I have in mind a large plant now being equipped with alternating apparatus for lighting and power distribution on thoroughly modern and improved lines. In this case, a system of three-wire, low-tension mains is to be laid over a large area. These mains will be fed at street corners from specially designed transformers in ventilated manholes. These transformers are to be of one hundred kilowatts each, and are to have a core loss of only 500 watts, or one-half of one per cent of the capacity. The efficiency of these transformers at one-quarter load will be higher than at full load, the principal loss being in the copper. Thus a transformer may be made to fill the same functions as a direct current feeder. If we are willing to introduce some drop between generator and main, we can get high light load efficiency with moderate cost, and we shall retain the important advantage that transmission is possible over long distances, with small losses, through the use of high voltage.

In no branch of electrical work has the improvement of recent years been more marked than in the manufacture of transformers. This improvement has not been brought about by any radical discovery as to the principles involved, but simply by study of the economic conditions. The quality of iron is a most important matter in building transformers, and the methods of handling and annealing are almost equally so. Then, the proportions by weight of iron and copper may be varied through a wide range, and the plan of arrangement of coils and iron are susceptible of endless variation. Every change of plan may affect the properties of the transformer as to self-induction, magnetizing current, hysteresis, eddy currents in core and copper, resistance loss and regulation. Thus there is much room for judgment in the design or purchase of transformers. At the price for which transformers can be bought, it is folly to use bad ones. Thousands of transformers are in use to-day that are fit for nothing but the scrap pile, and many are now being manufactured and sold that are no better.

REGULATION

The cause of bad regulation in most existing alternating plants is that each individual installation is connected to a separate transformer, and that in these transformers, and the wiring connected to them, there are losses varying with the load, which, of course, cannot be controlled from the station. Since regulation is a matter of most vital importance, we see that with primary distribution good regulation in transformers is imperative. To make transformers of specially good regulation, something must be sacrificed, either in economy of first cost, or in light load efficiency, or in both. Thus there is always an appreciable drop through resistance of wire in transformers, and this, combined with the drop in primary and secondary wiring, gives rise to serious vibrations in pressure on lights at different points.

Another fruitful source of potential variations on alternating circuits is found in the self-induction of circuits and also in the self-induction of transformers. The electromotive forces introduced by self-induction, being out of phase with the current, are variable in their effect, and give rise to troubles that sometimes seem erratic, although in reality they are governed by well defined laws, which, if properly observed, enable us to obtain accurate results.

MOTORS

Until very recently, the operation of motors from alternating systems has been practically out of the question, since no suitable motor has been obtainable. Thus alternating apparatus has been available only for lighting, while in direct-current stations motor load during the day has been a most important source of profit. It may be mentioned here that, while incandescent lighting is at the present time meeting sharp competition from other forms of illumination, the electric motor is growing very rapidly in popularity. It has taken the public a long time to gain confidence in electric power and to realize its usefulness. It is only within very recent years that large manufacturers have begun to use electrical power distribution to any great extent. At present, the work is being carried on very actively, and highly successful and economical results are being obtained in many large mills. As a means of power distribution, even for short distances, electricity has no rival; while for lighting, its advantages, though great, are relatively much less positive.

Although for many years efficient electric motors have been in general use, there are many central stations in whose business power distribution has not been a very important factor. There are several causes that have tended to restrict the use of electric power, among which we may mention the following:

Voltages that have been available for direct current work have not admitted of transmission to considerable distances.

Motors have required a certain amount of attention, which users were sometimes unwilling to bestow.

In certain classes of manufacture, the sparking of motors has been a source of danger.

The most important cause, however, has been that, as a rule, the same apparatus has not been available for the operation of lights and motors; consequently, central stations have not been in a position to make attractive propositions to large users of power.

The introduction of good alternating current motors has opened a new era in electric power distribution, and seems to promise a great extension of its uses. With these motors the difficulties of distance are practically eliminated, since there is virtually no limit to the voltage which can be used. The mechanical features of the motor are near perfection, since it requires no care save what must be bestowed on its self-oiling bearings. These motors can be so arranged that they may be operated with perfect safety in any part of a powder mill, or oil refinery, and, in fact, a number of them are being operated now in highly explosive atmospheres, where a spark would work destruction.

With facilities for electric power transmission thus improved, we may look for great developments in the sale of power from central stations. When it is profitable for large manufacturing establishments to put in electric plants for the purpose of distributing power on their own premises, there should certainly be profit in the sale by electric companies of power to large, as well as small, manufacturers.

The actual saving in fuel effected in the operation of a large mill by electricity for power distribution is ordinarily very large; often as much as fifty per cent. With good equipment, this is, however, only a small part of the saving effected by electrical distribution. The cost of coal seldom amounts to more than half the expense incident to the production of power, and in most cases it is a much smaller proportion of the total. If power is obtained from a central station, the coal is bought cheaper and used more economically, while the other items of expense will in many cases be almost a clear saving.

The introduction of electrical power distribution on any large scale, of course, requires the investment of a good deal of money in motors and alterations of plant. Power users are often slow to make these investments, because they are not familiar with electrical apparatus and do not realize the advantages to be gained. Repeated investigations have proved that users almost always far underestimate the cost of power. It is the business of the central station manager to correct these misconceptions, and to awaken interest in electrical methods. Of course, many companies are working zealously just on these lines. There is no question, however, that there is, in many of our large cities, a large amount of undeveloped power business. If electrical manufacturers can induce large mill owners to put in plants for electrical power distribution, central stations should be able to sell power to similar concerns.

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ordinary three-wire system, and afford an excellent means of secondary distribution.

Such a system as is illustrated in this figure, will give excellent service in almost any town; the low-tension mains taking care of the thickly built up portion and carrying the bulk of the lighting load,

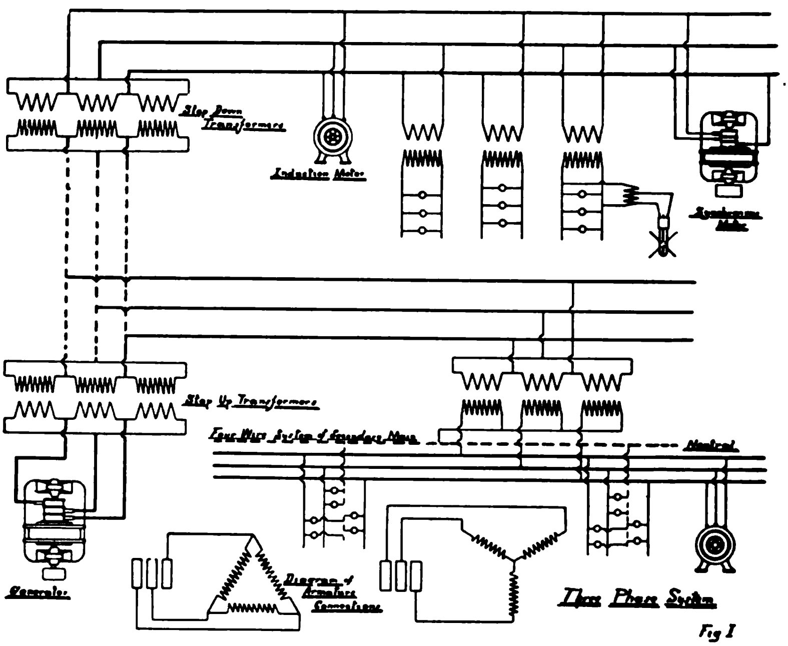
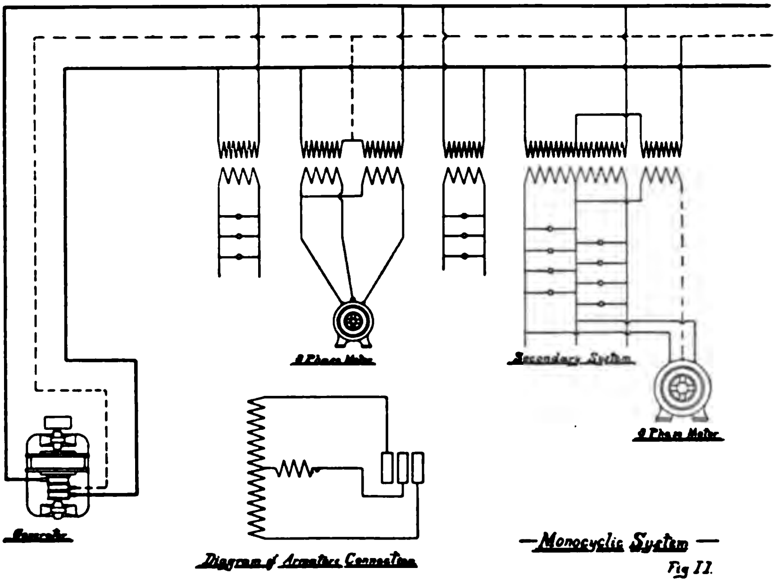


Fig I

while the high-tension distributing system covers all outlying portions and operates large power units. A number of large plants have been installed within the last two years, using the three-phase system, as here shown.

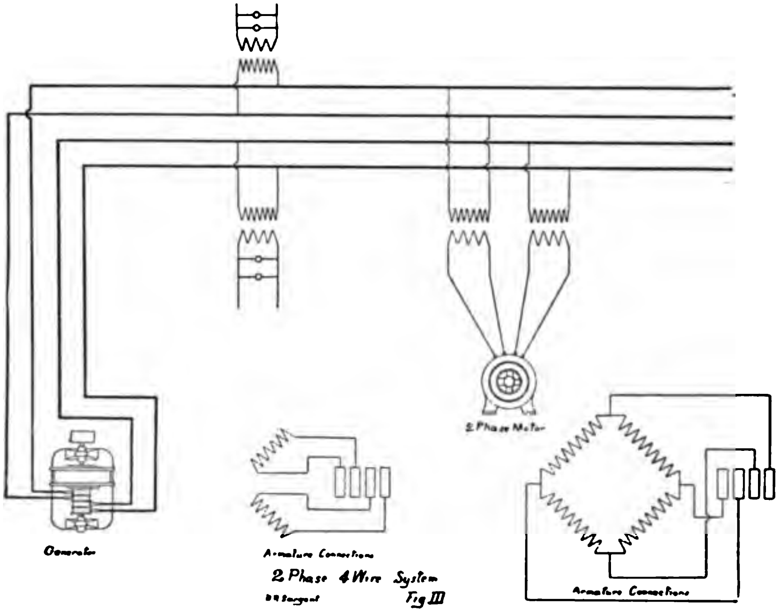
Figure 2 shows the connections for distribution by the monocyclic system. Here, all lights are connected single-phase between a single pair of conductors leading from the generator, the motors being operated from the same single-phase circuit in combination with a third conductor leading from what is known as the "teazer coil" on the generator. Here the simple three-wire system is used for secondary distribution, and if it is desired to connect motors to the low-tension mains, a supplementary transformer is used, which supplies a secondary teazer wire; to this and the outside wires of the three-wire system, the motors are connected.



—Monocyclic System—
Fig 11.

The great merits of the monocyclic system are that the number of conductors required for lighting and power distribution is reduced to a minimum, and that no unbalancing is possible. The operation of three-phase motors from this system is, in all practical respects, the same as when they are run from three-phase circuits.

Figure 3 shows the connections of the two-phase system, with distribution by four conductors. Here, the lighting is divided between two separate circuits, which must be kept balanced within certain limits, depending upon the regulation of the generator, or



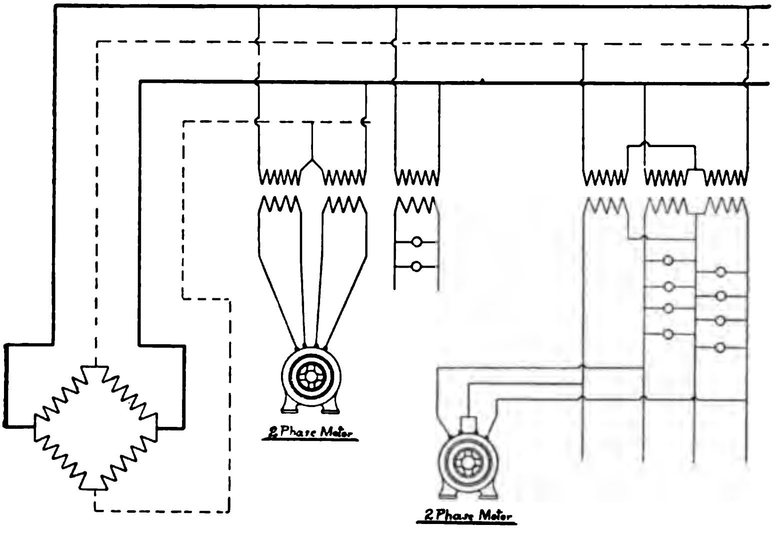
2 Phase 4 Wire System

Fig III

the amount of care that can be given to the adjustment of pressure on the different sides. Where motors are run, the two circuits must be brought together.

There is no economical and convenient way of operating secondary distribution from this system. Two independent three-wire systems could be operated, but these must be brought together when motors are to run. The complication of balancing such a system would be prohibitory.

The two-phase, four-wire system can be operated either from a generator with two independent circuits, or all four conductors can lead from one armature winding. Certain advantages may be claimed for both methods, and both have disadvantages.

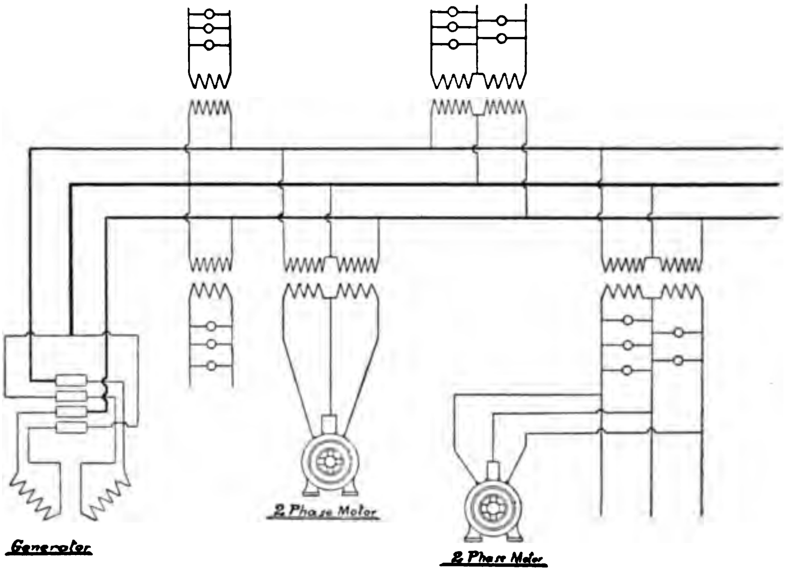


Single Phase System form 2 Phase Dynamo

Fig IV

Figure 4 shows a method of single-phase lighting distribution from a two-phase dynamo. Here, the two single-phase leads are taken out at points 180 degrees apart on a progressive armature winding. At points ninety degrees from those leads, two other leads are brought out; each of the latter can be used with the pair of single-phase leads to run one-half the capacity of the machine in two-phase motors. These two power loads cannot, however, be brought together.

The greatest disadvantage of this system is that, when carrying a single-phase load, a large proportion of the armature conductors are ineffective, and simply introduce useless resistance and self-induction in the circuit. Thus, with the same loss, the generator will deliver forty-two per cent more power as a quarter-phase machine than it will as a single-phase machine.



2 Phase 3Wire System

W.J. Sargent

Fig V

Figure 5 illustrates the two-phase, three-wire system, which has been used to some extent both for high-tension distribution and for distribution by secondary The principal advantage in this system is that one less conductor than the four-wire, two-phase system. Its disadvantages are that the insulation of the apparatus is subjected to a voltage forty-two per cent higher than that which is available in transmission, and that the self-induction in the lines and transformers causes an unbalancing of the voltages on the two sides of the system, accompanied by the distortion of the phase variation. The extent

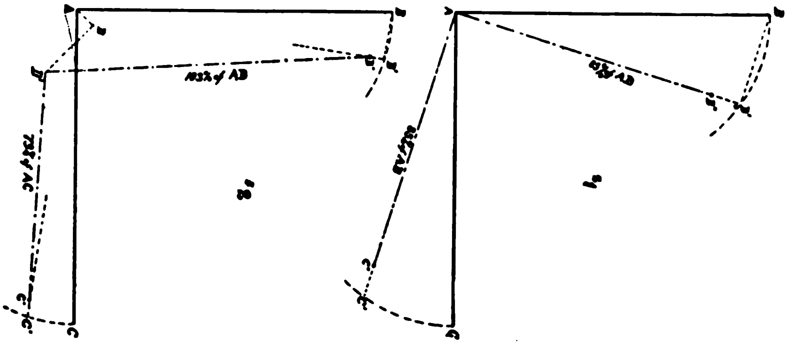


Fig VI

of this unbalancing depends upon existing conditions, and is very different in different cases.

Figure 6 shows diagrammatically the distribution of voltage with a given balanced load on a two-phase, four-wire circuit, and on the same circuit with one wire discarded, the third being used as a common return for the two sides of the system. S F and E G represent the two generated voltages on the four-wire, two-phase system. F F′ and G G′ represent the electromotive forces of self-induction in the lines of the separate two-wire branches of the circuit. F′ F″, G′ G″ represent the resistance drop in the two branches. E F″ and E G″, which are still at right angles, represent the two voltages at the end of the line.

The other diagram in Figure 6 shows the condition on the three-wire circuit. A B and A C represent the generated voltages in quadrature. C C′ and B B′ represent the volts of self-induction in the outside conductors. C′ C″ and B′ B″ represent the volt's drop by resistance in these wires. A D is the resistance drop in the third wire and D D′ is the electromotive force of self-induction in the third wire. Since this wire carries forty per cent more current than the others, A D is forty-two per cent greater than C′ C″, and B′ B″ and D D′ bear the same proportion to C C′ and B B′. The lengths of D′ B″ and D′ C″ represent the voltages on the two sides of the system at the end of the line. The angle C′ D′ B″ is the phase relation of these two circuits, and is less than ninety degrees. Thus, with balanced load, the sides of the system are neither equal or in quadrature.

The figures are so proportioned as to represent a circuit of "OO" B. & S. wire, operated at 125 cycles with ten per cent resistance drop on the four-wire system, and the same load and the same distance with three wires. With 1,000 volts at the generator in both of these cases, we should have 850 volts on each side with the four-wire system, and with the three-wire system, 730 volts on one side and 1,030 on the other. This assumes aerial lines with ordinary spacing of wires. In addition to the systems above described for distributing power by induction motors, we have other means of power distribution by alternating currents. The synchronous motor, for certain classes of work, is highly efficient and reliable, and is extensively used, although it will not fill all the requirements of general power distribution.

The rotary converter also fills a very important place in the engineering work of the day.

A synchronous motor is simply an alternating dynamo whose functions are reversed. They may be used either on single-phase or polyphase circuits. In its simple form, a synchronous motor has no power of starting itself on a single-phase circuit. On a polyphase circuit it starts with more or less torque as an induction motor, and will come to synchronism. As a rule, however, the starting of synchronous motors is not vigorous, and is accomplished by a large draft of current; hence their applications are limited.

A rotary converter is a synchronous motor of suitable construction, whose armature windings, besides being connected to collector rings, are also connected to a commutator. As the machine revolves at synchronous speed, brushes collect direct current from the commutator, this current being partly rectified and partly generated by the machine. This machine deals in direct and alternating currents and mechanical power; supply it with any one of the three, it will deliver either one or both of the others. It is most efficient when filling its functions as a converter from alternating to direct currents. Its capacity is then greater and its efficiency higher than when it runs as a generator or as a motor.

To illustrate the use of the rotary converter, I will describe an application now under consideration. The

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install a system of three-wire mains and a large storage battery. This battery would be installed in a second sub-station, conveniently placed. It would be charged from a pair of direct current machines, directly coupled to a synchronous motor operating from the 2,000-volt lines. The direct current machines would be used in connection with the batteries for supplying the three-wire system. The plan here outlined has many very positive advantages.

The pressure on the 2,000-volt system can, within certain limits, be controlled at the sub-station by adjustments of the field of the synchronous motor. With telephone communication to the power house, the control will be perfectly easy. The peak of the lighting load being borne by the battery, the generators can be loaded nearly to their full capacity with motors during the day. At night they will charge batteries, using water that would otherwise run to waste.

In both the plants described, the cost of labor would be very small, one man being enough to operate each of the sub-stations mentioned. The saving of labor in operation should be kept constantly in view in all engineering plans. Some of the greatest advantages in modern apparatus lie in its adaptability to such saving.

An infinite variety of conditions exists in different cities, and the question of electrical distribution must be carefully studied in each case, in order that money may be invested to the best advantage. An intimate knowledge, both of the apparatus available and of the commercial condition, is necessary to an intelligent decision in such cases. It is only through the exercise of intelligence and judgment of a high order that the best results can be obtained.

DISCUSSION

THE PRESIDENT: Is there any discussion on this important paper?

MR. DE CAMP: There certainly must be men here that are interested in this paper. Personally, I do not know anything about it, but I should like to hear it discussed.

MR. WAGNER: I should like to ask Mr. Emmet a question in regard to the comparative capacity of generators operating three-wire, two-phase and monocyclic. As I understood it, the three-wire, two-phase machine, when operating with three wires instead of four, would have forty-two per cent less capacity for lighting.

MR. EMMET: You misunderstood me; I said when operating single-phase, instead of two-phase.

MR. WAGNER: Yes; I mean single-phase, as that is practically the only commercially satisfactory way of operating these machines for large installations, where lighting is the principal load; that is, single-phase lighting from the two outside wires. Such a machine should have forty-two per cent greater capacity when operated two-phase than when operated single-phase; but it seems to me that, when compared with an ordinary single-phase machine, or with the monocyclic machine, it would have the same capacity for the same dimensions. . Is not that true? I should also think that the increase of capacity for two-phase operation would simply be at the expense of a small amount of copper in addition; so that such a machine, compared with a single-phase machine or with a monocyclic machine, should have practically the same capacity when operating on the single-phase system in connection with a three-wire, two-phase distribution?

Mr. Emmet: You misunderstood me; I said when operating "single-phase," not *two-phase.*

I will draw a diagram to illustrate the matter. We will assume that this is an armature, with winding distributed all the way around. The poles are here. If it were used as a two-phase machine, the connections would be placed at four equi-distant points. If it were wound as for single-phase currents alone, without any reference to two-phase use, the winding would not be distributed over the whole face of the armature, but a large part of the winding could with advantage be left off. The semi-circumference of a circle representing the actual turns of a wire on an armature having distributed winding, the effective turns for single-phase use are represented by the diameter. Therefore, we shall have a large proportion of the circle, or semi-circle, almost idle. By making it into a two-phase machine, we could increase its capacity without changing its proportions. By using the distributed wound machine as a single-phase machine, we have turns on the armature that are unnecessary. These turns have self-induction and resistance, both of which are objectionable. Hence it is not the best form of machine for single-phase use; and, if used as a quarter-phase machine, it will work much more effectively, since the generated voltages will then be this, this, and this, and this; the wire being nearly all placed in the best way to generate the voltage, and there being very little idle wire.

Monocyclic machines are built as single-phasers. They are built, not with wire distributed all over the armature, but placed where it will do the most good, and the rest of the armature left empty. We place a coil there and a coil there, and connect like that, so that there is a minimum amount of idle wire used.

Mr. Wagner: That is practically the same as stated; that such a winding as is represented there, with the same dimension machine, for the same capacity as the monocyclic, would require twenty per cent more copper.

Mr. Emmet: I do not understand the reference to twenty per cent.

Mr. Wagner: For the same capacity in lighting, such a machine would be of the same general dimensions, but would have approximately twenty per cent more copper on the armature, and would have the disadvantage of the additional self-induction and resistance of that copper when operating single-phase?

Mr. Emmet: Something like that.

Mr. Wagner: But would have nearly the same properties for operating motors as the monocyclic?

Mr. Emmet: It would have somewhat different properties from the monocyclic, but good properties for operating motors. Of course, these questions of the design of the machine depend altogether upon what regulation and armature reaction you want. In a machine with small armature reaction, it makes less difference whether you have a little idle wire on the armature or not; such armature losses are small, and the conditions of the losses in the machine are largely in the iron. Of course, it is not economical to run too small an armature reaction, as you increase the cost of the machine. It is desirable to use fairly large armature reactions in most cases, where it can be done without trouble and with proper regulation.

Mr. Ayer: Mr. Emmet states in his paper that he has in mind a proposed construction consisting of transformer sub-stations located at intervals, to feed the secondary lines. We know that is done abroad considerably, and I think it is done in your station in Chicago, Mr. President?

Mr. Wilmerding: Yes, sir.

Mr. Ayer: A three-wire distribution system, with the transformers located at intervals along the line in manholes. It is interesting to know that we are getting successful results with this arrangement in this country, and that its apparent practicability has been demonstrated.

Mr. Van Trump: I am operating a two-phase system, synchronous motor, driving Edison generators on three-wire system, and the system works beautifully with only one exception, which I am unable to explain at the present time. That is, with perfectly steady and even load on the Edison generators, and no fluctuations whatever in the speed of the generators, there appears to be a slight fluctuation on the alternating current mains, as if the motors tended to get out of synchronism. They do not pull out of step; you could not pull them out of step, even if you overloaded the Edison generators; but, at the same time, there is this peculiar fluctuation in the light on the alternating system only.

Mr. Emmet: It is probably due to variation in the speed of the prime mover, I should think. The synchronous motor has no mechanical connection with your moving system, and yet it has to keep in synchronism. It is simply held by the current in the line. As your synchronous motor tends to get out of step, it varies the voltage on the line considerably; it causes a distortion of the voltage, and might cause a rise or fall of the voltage. It becomes a leading or lagging current, according to its position. A tendency of the prime mover to vary speed would cause a tendency to pull apart; every time the generator varied the least bit in speed, it would tend to pull out, and in doing so would cause a variation in the voltage; and that might take almost any form of vibration. The synchronizing power is intermittent, and, the variation of speed coming at regular intervals, these periodicities might combine to cause almost any degree of fluctuation. The only remedy is in an absolutely uniform speed of your generator.

MR. DE CAMP: I remember that when the alternating system first came into use for central station lighting there were one or two things that confronted the users of that light which were very serious at the time. One difficulty was the running of lights and power on the same circuit. Another one was the question of transformers; in the first place, their first cost, inasmuch as every installation was supposed to have its own transformer; and, in the second place, the loss in the large number of transformers. It was said, however, at the time, that the multiplication of transformers was unnecessary, and the idea developed that you could have only one large transformer for feeding a large number of installations, which at least seemed very reasonable and plausible. At the next meeting of this association, however, if I understood the sentiments correctly, it was found that, under the extraordinary varying conditions and loads of a large number of installations distributed from one transformer, the losses in that large transformer at a light load more than counterbalanced the losses in the greater number of transformers under the original idea of this method of transformation.

I have had no experience at all in this business, but I know that there are some people here who have had, and I do not know but that I may have some time or other. It strikes me as a mere matter of business. Another serious thing now confronting the central station men, and which will increase as we get our wires underground, is the necessity of making house connections, which is a very great expense. Therefore, it needs no argument to show that it has come to a point where with 500 or 1,000 lights in ten or a dozen installations, which will run from minumum to maximum load, the one connection to this transformer will probably cost no more, or little more, than to make it to one small transformer or one small installation, and the distribution be made from that. I understood from the gentleman who read the paper that that had come to pass as a matter of fact; that these large transformers can be used for the large numbers of lights or large number of separate, independent installations. I did not understand, however, from the paper, or from the diagrams, how that has been brought about, and for that reason I hope that someone here who has been directly interested in that business will express himself; particularly as to the merits and demerits of the two systems, the single-phase and two-phase. I see a gentleman in the room who has given a good deal of attention to this subject, and who is well qualified to speak upon it. I should like to hear from Mr. Scott.

MR. SCOTT: Large transformers, for supplying a number of customers, will, in general, be more economical in the amount of power required for their operation, and also in the first cost, than the usual plan of supplying each customer by an individual transformer. The capacity of the large transformer may be less than the aggregate capacity of the small transformers that would be required. The cost of secondary mains may be prohibitive, however, if the district is a very large one, or if the service is underground and the cost of individual connections high. This question is one that depends largely on the conditions. In general, I believe in the use of secondary mains, and believe that this plan will be found the most economical, except in very exceptional cases.

I have noticed one or two points in the paper, which I will bring up for general discussion. In a comparison of the three-phase and two-phase systems of distribution, one of the points that confronts the customer is the measurement of the power on the two systems, both commercially, for the sale of power and light, and for determining the current in different branches or power in different branches. The three-phase system is so interconnected that, without elaborate or extended measurements or calculations, it may be impracticable to determine the load on the three circuits and the relative load on each; whereas, on the two-phase system, where the circuits are independent in action, except to a very slight extent, the measurement of the current in one circuit indicates the amount of current supplied to the devices connected with that circuit. In general, the amount of power measured directly in one circuit added to the amount of power measured directly in the other circuit, will give the total power. If the conditions are a little abnormal, or something is wrong—the very time when the ordinary operator wants to know where the trouble lies—the two-phase system with independent circuits seems to be the best arrangement; and I know some cases in practical working where the three-phase system has given much more trouble than is usually experienced with the two-phase system.

A method of secondary distribution that has not been widely used, but which is being introduced and which, it seems to me, has a useful future before it, is the three-wire system, with a modification in which only two wires are run from the central station, or in which only two secondary mains may be required instead of three, which reduces the number of house connections required. In this case, a 200-volt circuit might be used as secondary mains, and two connections be made to a customer. On the customer's premises a balancing coil is placed. This is a coil in the form of a converter with a single winding adapted for 200 volts; the two ends of the coil being connected to the 200-volt circuit and having a loop brought out from the middle of the coil, from which point 100 volts may be measured to either of the secondary mains, and which is used for the connection of the middle or neutral wire. This coil serves to preserve a balance between the two circuits, so that, although the number of lamps be greater on one circuit than on the other, the electromotive force will be practically balanced. This simplifies the three-wire system. The loss in balancing coils may be very slight. The balancing coil is a form of converter that will give a very large output, and its capacity need be only that required for the difference in the number of lamps on the two circuits; say there are twenty-five lamps on one circuit and seventy-five lamps on the other circuit, the capacity of the coil would be fifty amperes, whereas, the total number of lamps on the circuit would be one hundred. The size of the coil required for this difference in lamps would be the same as would be required for a converter of ordinary form with two coils for only twenty-five lamps, so the cost of these secondary balancing coils need only be quite small.

The system of two-phase distribution in which the generator is wound with closed circuit and the terminals brought out at four points, two being used for single-phase lighting and one of the other leads being used in connection with motor work, requires the use of but three wires to any point where motors are required. The use of four wires here is usual in many cases for motors, if the power required by the motors be large. The effective potential of distribution for motors is about 700 volts upon each of the two side circuits, if the lighting be done at 1,000 volts and the motor be run from three wires; but if all four wires be used, then the effective potential for motor service is 1,000 volts in the transmission line on each of the two circuits. Thus, if the quantity of power to be delivered by the motors is considerable, the use of four wires may lead to a saving in the cost of conductors, making it well worth while to run them. This kind of generator admits of this connection very readily. The only disadvantage of this system that has been pointed out—but it is said to be the greatest one—is the reduced capacity of the generator. That point has already been discussed. It is usually satisfactory to the customer to know that he can buy a dynamo for a certain price to do single-phase work, regardless of what the dynamo may do if operated in some other way.

The supplying of motors from a dynamo of this kind by three wires involves the two-phase, three-wire system, in connection with which the unbalancing of circuits has been pointed out. This unbalancing will tend to unbalance the motor circuits, raising one and lowering the other. This system is best adapted for a large percentage of lighting load, with a motor load as an auxiliary, as is the case in central station practice. In that kind of service, the unbalancing of the two circuits does not affect the lighting part, where closeness of electromotive force is required; but only affects the motor work, where the electromotive force is not required to be adjusted with the same nicety. With a motor load, the unbalancing due to this mutual induction between the two circuits, is not quite so great as it is on lighting loads The effect of the unbalancing in the example in the paper is extreme, and results largely from the high frequency of 125 cycles. At low frequencies, the effect would be very greatly lessened.

I desire to reinforce what is said in the latter part of the paper concerning the flexibility of the alternating system in actual practice. You have heard for a long time about the flexibility of this system, and its adaptability to all kinds of service. The examples given in the latter part of the paper show how that is now being done on a large scale. The Hartford, Connecticut, plant is one that has come to my attention lately, and I have gone into the details of it. One of the machines may act as a generator, driven by an engine, supplying power to the city service; or it may be run as a generator in multiple with machines at two different stations ten miles away; or it may be run as a synchronous motor for replacing the engine. This shows a flexibility that ought to find application elsewhere. The running of this current through rotary transformers, for supplying storage batteries, is also an application that ought to be adopted elsewhere. I have heard this plan criticised on one ground, and that is that it does everything, except that the storage batteries do not operate back through the rotary transformers and alternating current motor and make steam in the boilers.

MR. EMMET: Speaking of the unbalancing, I understood Mr. Scott to refer to the three-wire, two-phase system unbalancing; to this connection ,of the generator, which is illustrated in this figure (indicating); referring to the unbalancing that might exist on the supplementary motor circuits. You are not speaking generally of the three-wire, two-phase system as it is being applied to lighting?

MR. SCOTT: No, sir; it indicates that the unbalancing did not apply particularly to that system.

MR. EMMET: This system is being recommended for lighting, but at high frequency; and the unbalancing is more serious here with a non-inductive load than it is with the inductive load. You could reach a degree of inductance in the load where the unbalancing effect would be neutralized.

Another point made by Mr. Scott was in regard to the use of what I call compensators; that is, an adjusting device for supplying current to a three-wire system. In alternating current, we can use such compensators, just as Mr. Scott says; but in practice they would have to be somewhat larger. Anybody familiar with the use of the three-wire system as it has been applied in direct current work on a large scale all over the country, knows that even on a whole street the unbalancing at times will be very serious, amounting to nearly fifty per cent occasionally, and in single buildings and installations, it is, of course, worse. For this reason, all three-wire systems are installed with equal conductors for all three main wires. This unbalancing necessitates the use of compensators of considerable capacity—perhaps one-quarter the total capacity of the lights. These small compensators have necessarily a low efficiency; that is, they have large core losses. If their regulation is good, and they fill their functions properly and really maintain a close balance on the circuit, the core losses must be large. Such a large number of small compensators being used, the all-day efficiency is much lowered, as with many small transformers. It may be that in certain cases large compensators are desirable in connection with a three-wire alternating system, to help out at some remote point, making it possible to reduce the number of transformers in use in getting over large areas without trouble from unbalancing; but the general distribution of compensators in small units of ten or twenty lights, would seem to me to be hardly a practicable scheme.

MR. DOW: I began to use large transformers for 150 and 250 lights in 1889 with entire satisfaction, and found that the very best results could be had, and also economy in first cost, due to the fact that a block, where 500 lights were scattered in stores and offices, could be served by a 250-light transformer. I have had no reason since 1889 to change my mind, and my practice now is to put in the largest transformers I can use, when the conditions are equal as to cost, or even a little against the large transformer and the secondary main.

As to the two-phase, three-wire system, I can say from practice that where a large building is wired with the three-wire system—the Edison three-wire system—and the neutral is, as usual, of the same size as, or larger than, the two outer wires, in almost every case the two-phase system can be used without any trouble. In three cases within my knowledge, in buildings with 600 or 800 lights, we changed from the Edison three-wire system, and the users did not know the difference. The essential condition is that there shall not be a large drop in the building.

I wish to ask if there is nothing better for series arc light circuits, in connection with the alternating station, than the running of the well known series dynamos by a motor? Is there no prospect of series arcs, as commonly used for street lighting, being served by a rectifier system? In England, rectifiers have been put in use on fifty and sixty-light circuits.

MR. WAGNER: Mr. Emmet, I think, refers here to a synchronous motor used to drive countershafting, which, in turn, operates arc light generators. That could be done in any alternating current station, and the arc machines operated in that way from the alternating current generators. But it would hardly be an economical way to operate, unless it were desirable to operate the arc light machines at a distance from the station where steam power could be directly applied. I think we have all heard something about rectifiers being used in England, but I do not know of any accurate information or data that we have here in regard to rectifiers. They have been tried, and various experiments have been made with them, in this country, without any degree of success, I think; and I think it is hardly to be looked upon as a proper solution of the problem. Arc lights can now be satisfactorily operated directly from the alternating current circuits, either using a transformer for each arc lamp, or a transformer for a number of arc lamps.

MR. AYER: How many from a single transformer, and by what method of distribution?

MR. WAGNER: Mr. Ayer undoubtedly refers to an experiment that I am trying.

MR. AYER: I did not know that you had it under way; I thought you had solved it.

MR. WAGNER: I am experimenting in this same line of operating a number of large arc lamps for street lighting from alternating current generators.

The system used is one that admits of the use of the ordinary circuits, such as are used for series arc lighting, and with the lamps placed in somewhat the same way. As many lamps as desirable can be operated, I was going to say, but that is limited by the safe potential. I am now operating as many as seventy-five lamps on one transformer, and that does not seem to be the limit of the number that can be so operated. The system has not been in operation long enough to determine positively its success, and, therefore, I am not quite prepared to furnish all the details, although I hope to be able to do so before long. If it is a success, it will be a very economical way of operating arc lamps in connection with incandescent lighting by means of alternating current. Arc lighting, incandescent lighting and power can then be furnished from the same generator.

I should like to say a word further in regard to Mr. De Camp's question as to large transformers for incandescent lighting on secondary distribution. It has been found possible to design transformers for use with a proper system of secondary distribution so that the efficiency of each transformer shall not fall below ninety-four per cent with the smallest load that is likely to be operated from it. Such transformers are made in large units, preferably of the same capacity as feeder units, and placed at the ends of feeders; the entire system of distributing mains to be at low potential and operated by means of transformers placed at the feeder ends. The regulation of each transformer can then be considered as part of the feeder regulation, and, therefore, is not limited by the ordinary limits of possible variation on incandescent lamps; and with a possibility of a little poorer regulation (greater drop in the transformer), it is practicable to so reduce the iron or core losses in the transformer that the efficiency will actually be higher at a quarter, or even less, load than at full load, and the average efficiency will be about ninety-five per cent. Such transformers have been designed, and there seems to be no difficulty in their use. The combination in that way of the best direct current practice with the alternating current system, seems to provide an extremely flexible and extremely economical method of general distribution by alternating currents for large cities, by which power, incandescent lights and arc lights can be operated from the same set of secondary low-potential mains.

MR. AYER: It seems to me that Mr. Dow raised a question of importance, which has not been quite clearly answered, and that is as to the possibility of operating arc lamps,—a large number of arc lamps,—where they are a considerable portion of the station load—economically, directly, or through the medium of transformers, from alternating generators; whether or not a single class of generators will answer for all work, and do it economically. Mr. Wagner states that he is carrying on an experiment which, if successful, promises advantageous results. I should like to know whether he means to say that it will prove to be economical in a case where fifty per cent of the station load in arc lighting, as is the case in St. Louis, is to be supplied from the alternating generators; and, if so, whether the lamps will be operated from stationary transformers or motor generators supplying direct current, or driving existing arc dynamos with motors operated from alternating circuits. Can you do this in any better or cheaper way than by operating constant current series dynamos directly from the engine?

Mr. Wagner: The point is well taken in regard to the relative proportion of arc and incandescent light to be furnished by alternating generators, and as to the economy of so doing. I will simply say in answer that it is my firm conviction, which has not yet been proved, that it will be economical to operate, not only thirty per cent of the entire load with arc lamps, but it will be economical where the entire load is arc lamps; but, as I say, that is merely my opinion. I cannot say that it is an established fact.

Mr. Ayer: More economical than the present methods?

Mr. Wagner: Yes, sir. Not necessarily in the distribution; only from the fact that larger units can be employed and greater economy can be secured by the use of the larger units; economy in space, economy in efficiency and economy in attendance.

Mr. Ayer: It seems to me that it involves serious loss in one direction, which may be an important element of the problem, and that is in the distribution; especially in going over large areas distributing alternating current for arc lamps. How do you regard it? It seems to me that this is an interesting problem for us all.

Mr. Wagner: I am hardly prepared to answer that question definitely. My opinions want substantiation of some kind, and at present my statement would hardly be sufficient for these gentlemen; but in the course of a few months I hope to have thoroughly demonstrated the efficiency of the system. I hope to be able shortly to give some information upon it, and, if not done before, I hope at least to be able to describe the system at our next meeting. At present, I can hardly give any more definite information.

Mr. De Camp: Let me put the question a little differently; I think Mr. Ayer is on the right track. I ask Mr. Wagner if he had now thrown upon him the responsibility of installing a 1000-light plant, with arc lamps alone, whether he would do that installing from, say, four 250-light direct machines, such as we have to-day, or whether he would put in two alternating machines to do it, covering the same area of territory, say, a radius of three or four miles, distributing the 1,000 arc lamps in such manner as the public lighting required; whether you would do that with four direct arc machines of the best type, or whether you would take one or two of the best type of alternating machines: which would you do? Suppose you had a lot of investors and stockholders who should say to you, "Mr. Wagner, we will cut off your head if you do not succeed in doing this?" Suppose you had that responsibility?

Mr. Wagner: I can say that I have taken the responsibility for a larger number of arc lamps than Mr. De Camp mentions, and I cannot yet say whether my head is coming off or not. (Laughter.) It strikes me that Mr. Dow's question might be tersely put, by saying: "Is there to be a feasible series alternating arc lamp?"

Mr. Dow: I have been over this question annually for four years; I have to go over it again this fall,—the same identical question, with an investment back of it. I have heretofore had to advise the parties interested to put their money into old-line machines. I have succeeded in getting higher voltage, with greater economy in distribution and greater efficiency, from the larger machines of the old type; but, up to the present time, I have not found an ideal system. I can answer the question as to the lamps. This present year, series alternating lamps *do* work and can be made to work, and alternating lamps can be had that, apparently, will make just as little trouble as the old-line direct lamps. Last year, I should have had to say that there was no alternating lamp that could be relied to stay in service as long, without complaint, as the old style of lamp.

I can throw a little light on the rectifier subject, from recent correspondence with English engineers. The rectifier has been in use in England for four years, all told. It began with a twenty-light size and has got up to a sixty-light size, and there seems to be nothing to prevent its development beyond that limit, except the conservatism of the English engineers, who think that 3,000 volts is pretty near the jumping-off place. The efficiency of the method in connection with a first-class alternator is identically the same that I am getting in my own practice with fifty-kilowatt, direct current arc light machines. The efficiency is seventy-three per cent from the indicated horse-power to the output in electrical horse-power. The rectifier gives a pulsating current, such as might be had from a shuttle armature with a two-part commutator. The light is, to all intents and purposes, a direct current arc, and not the alternating current arc. A series transformer and regulating device give the same current characteristic that is obtained from the arc light dynamos in use in the United States. The device has considerable self-regulation. The maximum voltage in use up to date is 3,000 volts. The limitations appear to be in the commutator. On this side, we have succeeded in making commutators operating with 6,000 volts. I do not see why a motor commutator, synchronously driven, should not operate just as well as the commutator on a dynamo shaft.

I cannot see that there is any difference between the open-coil commutator of the well known types and the rectifier commutator driven by a synchronous motor. The two devices appear to be the same. I look for something in that line, and hope to see the same rectifier taken up by some American engineer, and experimented with as to its usefulness in connection with alternating transmission over long distances.

I believe that the line efficiencies I am now getting are as good as the average for public lighting; eight and one-half per cent losses in the lines. The lines, when fully loaded, will be more economical; the loss falling to seven and one-half per cent. I believe that is better than the average, and may be considered as a first-class representation of a modern station of that class. I doubt if an alternating system distribution through transformers, or an alternating current, will succeed in increasing the line efficiency; and I am afraid that high voltages, 5,000 or 6,000 volts, will be essential in public lighting as long as the city fathers consider it necessary to have lights in sparsely settled outlying wards.

I have considered as an interesting problem the question of getting down to 3,000 volts; changing from 5,500 to 3,000 volts. I found that I should have to double my investment in copper, and that the line losses would, on account of series distribution, be exactly doubled over what they are now, which would be seventeen per cent, instead of eight and one-half per cent. That would be the result involved in changing from 5,500 to 3,000.

MR. AYER: You state that the losses in the system with which you experimented, amounted to about twenty-seven per cent between the indicated horse-power and the output of the machine?

Mr. Dow: Yes, sir.

Mr. Ayer: That is the Ferranti system?

Mr. Dow: I have not experimented with that; I have advices concerning it. These figures are identical, to a fraction, it so happens, with the losses in my own system with direct current machines.

Mr. Ayer: Mr. Dow has a station that ought to show good efficiency in generating current for series arc lamps. What are your losses between your indicated horse-power and your lamps in your regular commercial operation?

Mr. Dow: If your engine is of the high speed type, in first-class condition, your friction losses may be as low as eight per cent; in practice, they will run up to twelve per cent; that is, the engine friction. If you use the largest dynamo available to-day, and your plant is so large as to require more than a couple of hundred horse-power, you will have to employ belts or ropes. Belts, I find, use practically the same amount of power as ropes. I have made very careful tests of ropes, and find that the losses run just a fraction over three per cent for full loads, and that they are nearly constant for all loads. That is to say, they vary for a fifty-kilowatt machine between 1,472 watts and 1,520 watts, with a load from nothing to a full load. You can say three per cent for belts or ropes in good order. The dynamo efficiency, coming next, will not exceed, under practical conditions, eighty-six per cent, if the dynamos are series arc dynamos of the size called, indifferently, 100, 110 or 125-light. Individual machines will give as high as eighty-nine per cent under the most favorable conditions; even a little beyond that. In practice, under the running conditions, you will find that eighty-six to eighty-seven per cent is about the best available. The line losses vary, in stations that I have measured and calculated, from six per cent for short distribution up to twenty per cent. I have had as high as twenty-five per cent in water-power work, where the current was sent a long distance. I think ten per cent will represent the average losses to-day. This, worked up, will give the efficiency I have quoted; namely, seventy-three per cent at the dynamo terminals; or, with line losses, say, sixty-six per cent at the lamps.

MR. EMMET: I want to ask Mr. Dow at what frequency these rectifiers have operated?

MR. DOW: Fifty periods; 6,000 alternations.

MR. EMMET: Mr. Dow describes an apparatus of Ferranti's that is run from what is known as constant current transformers. There is no means for obtaining a constant current, or substantially constant current, with a characteristic similar to the characteristic of the ordinary arc lamp dynamo, from an alternating circuit, without the introduction of a large amount of self-induction in the circuit; that is, we must have a lagging load. This, on a large scale, is objectionable, particularly if anything else is operated on the same system. It seems to me to be one of the worst limitations of the rectifier system. The frequency at which the rectifier has to operate to go on alternating circuits, makes it very different from the commutator on an open-coil arc machine. For example, a Brush machine—at what frequency do the Brush machines operate, Mr. Black?

MR. BLACK: What speed?

MR. EMMET: Yes.

MR. BLACK: Five hundred to 700 revolutions; four-pole machine.

MR. EMMET: Four-pole machine at 700 revolutions gives twenty-three periods. It is fifty cycles at which Ferranti operates his.

MR. DOW: The Ferranti machine operates also at eighty-three.

MR. EMMET: The question arises as to how commercial Ferranti's machines are. In Europe, they do not operate so many long arc lines as we do. The conditions do not exist where a large number of arc machines in one station operate over a wide extent of territory, such as surrounds many of our towns. Although we know that they get results there, we do not know how well they compare with results that we should consider commercial in this country. It is a little strange that the European rectifiers have not been shown here more than they have, if they are an entirely practical thing.

MR. DE CAMP: Going back to the subject of which Mr. Dow speaks, he gives eight and one-half per cent friction loss in his engine.

MR. AYER: From eight to ten per cent.

MR. DE CAMP: You name eight to ten per cent for high speed engines; what do you mean by that?

MR. DOW: I have one Westinghouse engine at 350, which shows eight per cent; ten per cent is about fair for that type. My triple expansion engines show twelve per cent.

MR. DE CAMP: Speaking of that, you mean simply running that engine to speed under a given pressure?

MR. DOW: I mean the friction; the engine itself absorbs ten per cent of the indicated horse-power at rated load.

MR. DE CAMP: Then you come to the friction of the belts. By it I understand that you mean simply the power required on account of the weight of the belt and its contact on the pulleys?

Mr. Dow: Yes, sir.

Mr. De Camp: That is three per cent. Do you take into consideration loss on account of slipping?

Mr. Dow: These losses are calculated by a method that involves all those factors.

Mr. De Camp: Your three per cent covers loss of power due to slipping?

Mr. Dow: Yes, sir.

Mr. De Camp: Then you come to the loss in the dynamo. Are you figuring there on belting directly from your engine to the dynamo; you are dispensing with shafting?

Mr. Dow: Yes, no shafting. It should not be there; it is not necessary. (Laughter.)

Mr. De Camp: Suppose that you were running under a different type of engine; a Corliss engine?

Mr. Dow: That is a condition that is accidental, not designed. You have not got that before you for discussion.

Mr. De Camp: Now, as to the merits between a certain type of engine that you are using and a certain type that somebody else may be using, I doubt if you could dispose of that subject offhandedly.

Mr. Dow: The introduction of a countershafting will usually increase the loss from nine to ten per cent, if the shafting is in good order; if otherwise, it may be twenty per cent.

Mr. De Camp: The friction of your shafting would be calculated just the same as your friction load in your engine; simply an additional weight load?

Mr. Dow: Yes, sir.

Mr. De Camp: That makes, according to your figures, thirty-five and one-half per cent?

Mr. Wagner: I wish to return again to arc lighting from alternating circuits. I do not wish to be misunderstood. Mr. De Camp asked me in regard to the installation of such a system. I would answer that central station managers who are anxious about their heads will do well to stick to well-tried systems. Most of my directors have heard from many electricians over the country that the system I am trying will not work, and they ought to know. (Laughter.)

MR. BLACK: One important point has been left out of the discussion; that is, the efficiency of the alternating current lamp as compared with the direct current lamp. What we want is the maximum amount of light with the minimum amount of power; but in all photometric tests that I seen accounts of, the light derived from the alternating arc has not been more than about fifty to seventy-five per cent of that derived from the direct current arc on the basis of the same watts being dissipated in each. In that case, it seems to me that it is absolutely impossible ever to run commercial arc lights from an alternating system without a rectifier of some description.

The following letter from Professor Elihu Thomson was then read:

"SWAMPSCOTT, Mass., May 3d, 1896.

"MR. GEO. F. PORTER.

"MY DEAR SIR: In response to your favor of the 3d April, I desire to say that I shall have to be content to be with you in spirit, but not in person. I am confined to bed with a bad sprain and fracture of bone in the right ankle. I regret exceedingly that the accident will take me away and keep me away from travel or regular work for some weeks.

"Please inform those interested concerning this unanticipated cause of absence.

"I can only send my best wishes for the success of the convention and the exhibition, in which interesting events I am prevented from taking an active part.

"Truly yours,

"ELIHU THOMSON."

THE PRESIDENT: I should like to call the attention of the members to the fact that the railway certificates should be presented as early as possible to the master of transportation, Mr. C. O. Baker, Jr., in the secretary's office.

On motion, the convention adjourned until 2.30 o'clock.

FOURTH SESSION

The convention was called to order at 2.30 P. M., by Vice-President Nicholls.

A paper, prepared by Mr. Luther Stieringer, on the evolution of interior conduits, was read by Mr. E. A. Armstrong, Mr. Stieringer not being present.

EVOLUTION OF INTERIOR CONDUITS FROM THE ELECTRICAL STANDPOINT

9

The fact that a conference, organized under the auspices of this association, to secure better electrical construction, was held recently in this city, is in itself an evidence of the importance attaching to the general subject. But the national and influential character of the bodies represented is further proof of the anxiety felt in regard to the matter, and the desire for a higher grade of work. In particular does that feeling concern interior wiring for buildings of all kinds. There is a feeling that the future and prosperity of electricity depends on the methods by which current is introduced into and distributed through modern offices, modern houses and modern halls. It is felt that, in many respects, electricity has reversed the methods of road-making. In almost every city the roads are fairly good; in most they are excellent. When you strike the country, you are likely to find boggy, rocky, uneven tracks and paths, which cause disaster to the buggy and the bicycle. In electrical practice, we have got our main roads in pretty good shape; but when we come to the city line, or, in other words, to the confines of the building, there we begin to strike the wildest and strangest vagaries in the plan and construction of paths for the current that can possibly be conceived. Where the electrical road building, or, as the French say, "canalisation" should be best, it is worst. Let us examine the problem thus disclosed, with the object of finding a plan of improvement. Let us see where the art of interior wiring started, the point it has attained, and the end at which it should be aimed.

Webster defines a conduit as a pipe, canal, channel, or a passage for conveying water or fluid.

According to the standard rules (National Board of Fire Underwriters, 1896,) the object of a tube or conduit is to facilitate the insertion or extraction of the conductors, to protect them from mechanical injury, and, as far as possible, from moisture. Tubes or conduits are to be considered merely as raceways, and are not to be relied on for insulation between wire and wire, or between the wire and the ground.

In the development of interior electrical distribution, it is necessary to briefly review the history of the use of the conduit for water, gas, and steam, especially before the introduction of the powerful electric currents necessary to supply light and power.

GAS FITTING

In the early gas installations in England, lead pipe was used quite extensively. The work was performed at that time by the plumber. The term "gas-fitter" originated and became a special trade name in the United States when iron fittings were introduced. Prior to that stage in the art, fittings were improved by brazing a saddle of brass on a piece of iron pipe. This saddle had a protuberance threaded with a male thread, and after being brazed to the pipe was drilled for a gas way, thus forming an outlet to which a coupling could be attached. The present form of gas-fitter's tee is an equivalent of what has just been described. Lead was never employed in the United

States for gas-piping, except for meter connections and temporary work.

In one of the earliest gas systems in Philadelphia, in 1835, iron mains were run on the outside of the houses, with stop-cocks arranged so that the gas might be turned off before the family retired for the night. This was thought necessary for security, on the supposition that otherwise some unknown cause might develop leaks or trouble. In France, at one period, all gas-piping in interiors was left exposed for more ready inspection. The crude method of installation in that day did not inspire confidence in concealed pipes.

Service stop-cocks are still placed near the street curb, as a provision principally against fire, in case the meter or other connections in the interior of the buildings be melted or dislocated and the escaping gas continues to do damage.

On the Continent of Europe, there is generally a main tap on the exteriors of premises, attached to the service pipe, for the purpose of shutting off the gas when desirable.

At the time of the famous Barnum Museum fire on Broadway and Prince street, New York, the inability of the firemen to get at such service cocks, owing to ice-covered débris, permitted the escape of gas inside of the building line to such an extent that the volume of flame rivaled a burning gas well. This continued for several days before it could be controlled.

Escaping gas is more dangerous than any other medium distributed in a building. Many years of experience have proved that the use of iron piping to convey gas has minimized all possible dangers from leaks or other causes. The early fitting art, by its use of split dies and poor material, was responsible for any lack of confidence as to the ability to confine water or gas to the conduits or pipes.

The reliability of gas, water and steam conduits in interiors, and the general public confidence in them to-day, can be traced to the creation of the solid die for cutting threads to proper fittings, to superior pipes and to standard threads.

In the United States, prior to 1860, neither water nor gas distributions in buildings, especially in residences, were very extensive. The vitiating effects of gas on the atmosphere of a closed room prevented its use in Europe until a comparatively recent date, except in corridors, assembly rooms, factories and public places. Sleeping apartments are still rarely supplied in England. In this country, however, at the period mentioned, gas was much more extensively used, both in residences and elsewhere.

At one period, when cast-iron street mains were very expensive and costly as compared to present prices, several attempts were made to substitute pipes of other material. In a city in the western part of England, an extensive trial was made of transmitting gas through brick conduits and earthenware pipes like the drain pipes of the present day. Pipes of earthenware were used on an extensive scale in some towns in France, the joints of which were made of Roman cement, and the services attached by punching a hole in the main and inserting the end of the leaden service pipe, which was secured with cement. This method resulted in complete failure, and several gas companies were all but ruined by resorting to it. The excessive cost of cast-iron retarded gas as well as water distribution, enforcing even the use of wood coated with asphaltum as conduits for street mains. During the infancy of street gas distribution, cast-iron pipes were made with flanges and put together with bolts and cardboard washers. This practice had to be abandoned, and lead joints were at length universally employed. The same method was adopted in water mains. The first street mains for gas, laid in 1807, in Pall Mall street, in London, were of lead. Tinned iron and copper were also used. Paper pipes were in use early in this century for water and gas mains. When used for the latter purpose, they were lined with lead to prevent the hydro-carbon in the bituminized paper from being acted on. Tile pipe as large as twelve inches in diameter was also used.

PLUMBING

Early plumbing did not comprehend any installation beyond water required for culinary or other special purposes; the introduction of the bath and more lavish use of water only following the more plentiful supply from comprehensive "Central Station" water systems.

It is not many years ago that water had to be drawn from wells and other sources, and carried to receptacles for short storage. Where the luxury of a bath was introduced years ago, it was installed in an outhouse, or an extension to a dwelling or a building, to simplify and reduce the cost of installation. This generally required an extension of the pipes to serve points distant from the street service. For this purpose lead pipe only was used, which caused much annoyance and trouble. The settling of the soft, pliable pipe, if not thoroughly supported, prevented a thorough drainage; and in cold weather the pipes were constantly freezing and bursting. This was the origin of the plumber-millionaire joke.

The use of saws, chisels and nails by mechanics in the performance of their work, proved to be a constant source of injury to the pipes; and, as these injuries frequently occurred when the water was turned on, great damage was done to frescoings and furnishings before the source of leakage could be discovered and corrected. Rats and mice would also frequently gnaw into such conduits and cause the escape of the water.

One of the first deviations from the lead-pipe practice on an extensive scale was in the latest Western Union Telegraph Building, in New York, on Broadway, in 1870.

To avoid the difficulties before mentioned, this building was piped with tin-lined brass pipes. From that time on, the practice became general of using in all concealed spaces galvanized iron or brass pipe, which could be relied on as safeguard against any of the aforesaid difficulties, so that damage might be avoided.

STEAM HEATING

This is another form of distribution now in general use. It is effected with perfect safety when installed according to modern practices, with metal pipe of sufficient strength to withstand the pressure from within and injury from without.

In the three systems of distribution, which have been outlined as briefly as possible, viz., Gas, Water and Steam, the following should be noted:

Water produces damage only when allowed to escape, and then only by flooding interiors.

Steam is so well harnessed that its escape in a measure does not differ materially in the results developed by water, except that it may cause personal injury through scalding.

Gas, however, unharnessed and not properly confined, is capable of two-fold destruction: 1st, Its ignition may set fire to surroundings; 2d, Its explosiveness, when pocketed and under suitable conditions. It is also extremely poisonous when escaping and unlit.

It is very rare that dislocation or deterioration in gas piping results harmfully in properly installed systems of gas-piping in interiors.

The fixtures, of course, are more or less handled, and are liable to derangement; but as they are thoroughly accessible and in full sight, any leaks are easily discovered and corrected.

ELECTRICAL DISTRIBUTION

In 1881, upon the introduction of the incandescent light, which was designed to supplant gas systems, the promoter's contention, outrunning the inventor's more modest claims, was that the new electrical illumination required the simplest kind of wiring at small cost. The purchaser's objections to duplicating a system of distribution in a building already containing gas-piping, induced the promoter to make further statements in the direction of cheapness, which culminated in the claim that the gas pipes already in place could be utilized, and that the electrical conductors could be inserted within them. This was inexplicable to the purchaser, who was told—what at that time became a standing joke—that Mr. Edison had devised an electric bug, and all that was necessary was to attach a wire, insert the bug in the pipe and turn the current on, and it would crawl along and carry the wire with it to any required destination, thus enabling the wire to be placed without difficulty and at little cost. As a matter of fact, Mr. Edison was trying to get the "bugs" out of the system.

With the first installation, this question of conductors and their location became one of very serious moment. The method employed was that of a distribution based on a circulation similar to the arteries of the human body, diminishing in size from the source of supply to the points of requirement. Fuses were only applied at the generator, or source of supply, and at the lamp-holders, and were designed for this special protection only. Very few intermediate fuses and cut-outs were used, and these were placed in the most inaccessible and unusual positions, and only on one side of the circuits.

Paraffine-covered wire, as employed in prior telegraph and annunciator installations, was adopted for electric light work. This often became heated to such an extent that it frequently set fire to the insulation, and produced burning wires for long stretches between floors and ceilings and under floors. When this came to the notice of the underwriters, they insisted on a non-inflammable wire, commonly known as the "Underwriters'" wire, which had a coating of zinc paint on a cotton fibre braid. This covering, while not being combustible, permitted infiltration of moisture, which caused electrolytic action and the consequent rapid destruction of the wire. Some of the wire gave such bad results in moist places that a twin wire with bituminous covering was substituted. It was known as "Paragon" wire. Much of this for a time gave very good results. The material, however, deteriorated, principally on account of air checks and cracking insulation, and its use had to be discontinued.

About this time, various grades of composite and rubber-covered wires of high insulation were introduced with satisfactory results. As in much of the early work done, the wire was supported on cleats and treated practically as if it were bare wire; and as concealed wiring was generally placed in dry structures, defects did not manifest themselves so rapidly as they would otherwise have done.

In the early history of electric lighting, an interior conduit system of wiring was employed. The importance of concealing the conductors in the fixtures necessitated considerable simplicity in wiring to make the same practicable. This was accomplished in the very first commercial fixture, and the general plan then evolved is now in universal use the world over, having completely displaced all attempts to introduce special electric structures.

The attempt of the electrician of that period was to create these special structures just alluded to, based on the lines of his prior practices in telegraphy and other feeble current-carrying arts, introducing contacts, binding posts and other paraphernalia, believing that in this way the whole fixture art would be overturned to make way for the new illuminant. Fixtures, however, are the same to-day as they were before the electric lighting art, except in the modification of the internal portions so as to admit of inserting or withdrawing the conductors, and in the angle at which the light can be directed or suspended.

Internally wired fixtures have been and are placed in all kinds of positions. Where the interior of the tubes has been exposed to moisture, the inlets have been closed, thereby preventing air circulation and consequent precipitation of moisture. No appreciable deterioration resulted, even where poorer grades of wire were used.

Gas pipe or brass tubing, without any insulation, has been the form of conduit in which conductors were placed in fixtures, the only additional provision in a plain iron pipe that was used being in the case of combination fixtures, where the outside of the iron pipe was taped to prevent chafing of the wires. This was abandoned as soon as the manufacturers recognized the necessity of using properly insulated wire and of so constructing the metal covering of the iron pipe as to prevent chafing.

In a paper read before the World's Fair Insurance Congress at the World's Columbian Exposition in 1893, the value of iron conduits was fully recognized, an extract from which is given in the appendix to this paper.

So far as interior electric conduits are concerned, it may be said that they were in use with the first installation, and have been continued, representing the most advanced form of the art, in the large number of fixtures that have been installed. Many of the early plants, such as in mill work, and some of the early expositions, have almost as many feet of conductors in the long pipes pendent from the ceilings as there is wiring in the branch circuits.

When it became necessary to conceal wiring, it was common practice to insert mouldings (a legacy of the telegraph installations) in floor beams and put the conductors into the grooves provided. There were also many instances at that time of the separation of gas-pipe lines and of their utilization for the purpose of inserting conductors, rather than mar the walls or surroundings by external placement. In the fire-room of the steamer "Pilgrim," in 1883, several hundred feet of brass tube were placed without any insulation other than on the conductors. Several other steamships about that time had galvanized iron pipe as conduits without any insulation. It gave good service.

The use of speaking tubes to serve as conduits was quite frequent in early electric light work. A notable installation of this sort was in a large residence at Greenwich, Conn., in 1887. Although the best electrical talent was employed, the mechanical work did not permit of inserting or withdrawing the conductors freely, and they became more or less fixed in position, with the result that the installation had to be overhauled. In fitting up a cottage on the same premises with electric light, small brass-pipe tubing was used. The runs were not long, and the bends, or sweeps, were, therefore, easily placed, and could be concealed without difficulty. Ordinary flexible cords were inserted as conductors, giving satisfactory results. This tube not having been closed at its terminals, permitted circulation of air, and developed moisture, which, however, did no harm.

About this time a twin conductor was evolved, based on comparatively no insulation. This twin conductor was patented. The copper conductors were separately covered with a thin cotton covering, without any high insulation. These were laid side by side, and both were covered with additional insulation.

The object in closely associating these two conductors in this way was to assure the blowing of a fuse in case of a leak or short circuit. The proximity of the conductors would produce a low resistance arc, the rush of current at that point resulting in the rupture of the fuse. This method was subsequently put into commercial practice, but had to be abandoned, as it developed more faults than the evil it sought to correct, and largely assisted in establishing the use of highly insulated conductors in conduits and raceways in interior installations.

Shortly after the Greenwich installation, a paper tube, impregnated with bituminous compound, was produced. A considerable quantity of this tube was marketed before it was found that, if concealed in plaster or cement, it failed to resist chemical action that ultimately destroyed it.

To overcome this, the paper tube was covered with a thin brass sheeting or covering. This, while to some extent resisting chemical action arising from proximity to plaster or cement, was, nevertheless, susceptible to mechanical injury.

During the time that this brass tube was being developed and marketed, the value of an interior conduit system as a means of readily inserting and withdrawing a conductor was fully recognized by engineers and constructors.

A paper was read before the meeting of the National Electric Light Association at Detroit, in September, 1886, entitled "Some Features of Incandescent Lighting and Wiring." In this paper, the advantages of a system of distribution and control *versus* circulation, were fully recognized. Distribution of current in buildings became more systematized through the adoption of a system of distribution and control. (See Appendix.)

The distribution and control system was first brought into comprehensive use in the St. Louis Exposition Building, in 1885, in a permanent plant of over 5,000 lights, in which all the circuits were derived from points of distribution, there being some twenty or more distributing points arranged in the building, with over 400 or 500 local circuits.

Had the system thus introduced at that exposition been in general use, as it is now in the best practices, conduits would long ago have been extended in the iron, steel or other metal form, from the fixture back to the source of supply, thus filling the gap between the two points, and preventing any disturbance or injury to conductors placed within them.

In the construction of buildings, various artisans must in turn complete their work. The gas-piper, the plumber and steam-fitter, each has his operations so arranged that he can practically complete the work before the plastering, woodwork and general finish has even been commenced.

The use of the conduit likewise permits in branch lines, such as are confined to rooms, the placing of the electrical material in advance of the plasterer or trimmer, if such conduiting be properly arranged between distributing points to which the mains are brought.

At the World's Fair, in 1892, the question came up as to the protection of the conductors, some of which were carrying 2,000 volts alternating current within the buildings. As these conductors in many cases had to be placed under the floors, it became a very important matter to secure them against injury.

In considering various methods of protection, all forms of manufactured insulated tubes then on the market, including various kinds of mouldings, were rejected, as not affording that freedom from the damage that nails, chisels and other casual or malicious interference might cause.

As a result, the Chief of Construction authorized the use of plain iron pipe, relying entirely on the sufficiency of the insulation of the conductors therein placed. The large amount of bare iron pipe so used gave absolutely satisfactory service.

The results of this experiment proved conclusively to the various engineers and constructors attached to the electrical work of the Columbian World's Fair, the value and sufficiency of the protection afforded by bare iron pipe, since which time they have one and all been firm advocates of its use for conduit purposes.

In 1889, at the retail store of A. T. Stewart, Broadway and Tenth street, New York City, there were installed over 3,000 lamps. All the primary feeders connecting the various converters were placed in gas pipes. The pipes were laid on the iron ledges of the building. Although these pipes and wires, of a total length of about two miles, were placed by inexperienced men, they were in constant and successful use for over five years, conveying satisfactorily a current of fifteen amperes and 1,000 volts, or 200 horse-power, although constantly exposed to the weather. In the subsequent installation of an isolated plant, the above mentioned conductors were again used. In New York and elsewhere, thousands and thousands of feet of plain iron pipe have been in use for many years with high-pressure currents operated in them; and there is probably more non-insulated iron pipe in use to-day, much of which was installed many years ago, than of all other forms of insulated conduits thus far placed.

To further illustrate the foregoing facts, it may be said that there are about 30,000,000 incandescent lamps in use to-day. Assuming that there are but six inches of pipe to each lamp fixture, we have a total of 15,000,000 feet, or several thousand miles, of non-insulated iron or brass pipe in use in fixtures alone; no insulation of the same, other than that furnished by the conductors, having been found necessary.

The best experience of the past fifteen years in interior wiring has demonstrated the following facts:

1st. Indiscriminate wiring with staples is universally condemned.

2d. Cleat wiring is admissible in exposed work where the circumstances admit, but not in any concealed work.

3d. Wires imbedded in plaster, depending on the insulation only for protection, are condemned.

4th. Lead-covered wires are also condemned, except where protected in a conduit.

5th. Wires in mouldings do not afford mechanical or chemical protection, and are only admissible in surface work.

6th. Wires carried in plaster and covered with split or zinc tubes to prevent injury by trowels, are condemned.

7th. Glass or porcelain insulators can only be utilized in special cases of exposed work.

8th. Paper tubes do not afford absolute mechanical and chemical protection.

9th. Insulated tubes covered with a thin coating of brass or other metals, do not afford absolute mechanical and chemical protection, but, in exposed work, they are, to a certain extent, admissible.

10th. Woven fabric conduit does not afford absolute chemical and mechanical protection.

11th. Heavy insulating covering, integral with the insulation, offers no absolute protection against mechanical and chemical injury, and is analogous to rubber tubing for gas distribution installed throughout a building.

12th. Concentric wiring is practiced in England with satisfactory results, but is not in use in the United States. It offers many possibilities in the direction of a solid and fixed system.

13th. Paper-lined iron or steel pipes, known as "Iron-Armored Conduit," "Builders' Tube," "Armorite," "Clifton," and plain iron or steel pipe, are the only conduits that can afford absolute security against mechanical and chemical injury and assure permanence.

The users of conduits having a lining of insulation, in order to be consistent, should place only bare copper conductors within them. There is only one insulated iron tube, however, in use at present in which such practice is carried out. This is for underground purposes. A recent installation at Niagara Falls is one of the latest examples of this system. The requirement for insulation of interior conductors is five megohms per mile. In view of this, it can hardly be said that a tube is "insulated" in a commercial sense when, if subjected to the tests applied to conductors, it deteriorates to such an extent as to be practically of no value. Such insulation in conduits is, on its face, of no value whatever to the conductor, which for its efficiency must depend entirely on its own insulation.

Although a period of fifteen years has elapsed since the introduction of the incandescent light, it cannot be said that a standard system of wiring, having the elements of permanency to recommend it, has yet been adopted. Cleat, knob, moulding and other makeshift methods, are still resorted to. Similar makeshift practices were in use in the early gas and water installations, such as the placing of the conductors on the outside of walls and ceilings. The concealment and proper placement of such conductors brought about a comprehensive standard of practice that is now nearly universal.

Conduits, when properly devised to protect insulated electric conductors placed within them from mechanical and chemical injury, make such protection absolute, and are accepted by all intelligent architects, engineers and constructors as permanent. Such a conduit, to be practicable, must be a pipe, or tube, of injury-resisting material; as, for instance, iron gas pipe, which has proved its durability in other, more hazardous systems of distribution. The cardinal principle covering all conductors is that they must not allow leaks. The insulation on an electrical conductor, if possessing the property of resisting injury and deterioration, might be considered as self-sufficient. No such insulation, however, has been, or is likely to be, developed. There is one other embryo system that may be developed, possessed of sufficiently desirable features to yet become a standard and a rival of the conduit for interior distribution, viz., the solid, or fixed, system, in which the conductors are firmly fixed in position, with the insulation in an injury-resisting metal tube, or covering. These can be made of any length, to suit all requirements.

Another form of a solid system is seen in the cable largely in use abroad for underground work. Its lead covering preserves the insulation, and the metal armor prevents mechanical injury. It has been suggested that this cable could be made sufficiently flexible to be installed from outlet to junction, and junction to service. There certainly are situations where it can be employed to advantage.

Some years ago, what is known as the concentric wiring system was introduced in England, where it is now in extensive use. "In this system, the central conductors must be surrounded over their insulation by a metallic sheathing of conductivity equal to or greater than the core." The concentric system has not been employed in this country, although leading electrical engineers have long ago indorsed its practicability and usefulness.

A company recently put on the market an iron tube (gas pipe) with a lining of thin paper impregnated with an insulating compound, claiming for it the same values in insulation that were possessed by thicker paper-lined tubes already marketed, and also claiming the further advantage of a large bore with the same outside diameter of tube. This concern was absorbed by a company manufacturing the heavy paper-lined iron conduit, and since this consolidation the thin-lined tube has disappeared from the market.

An interior electric conduit of steel, thinner than ordinary gas pipe, with brazed seams, is being introduced. It is undoubtedly intended to be lined with paper, similar to the iron-pipe conduits now made by several firms. The special advantage claimed for this steel tube is its cheapness. A large amount of similar tube has been in use for various purposes for some time. Experiments are now being made by various parties with steel and mild steel tubes of injury-resisting qualities and in special forms and fittings, with the idea that they can be produced at a cost lower than gas pipe, and, if found necessary, can be coated or lined with insulations of any kind or thickness.

Iron pipe coated with rubber and other compounds has been in more or less general use for gas and water services for many years. These tubes were coated principally for the purpose of preventing oxidation. The present practice in the case of gas and water mains, whether large or small, including all cast-iron pipe used in plumbing, is to immerse the same in a hot bath of bituminous material, for the purpose of preventing escape of gases and oxidation. Such a coating in interior conduits would produce a smooth surface which may be of value, and at the same time cheap and serviceable. So far as the insulation of interior electric conduits is concerned, however, dependence must be placed in any and every case on the covering of the conductor and not on the lining of the conduit. There need be no restriction as to the kind of material from which interior conduits are made, provided they conform to the requirements of perfect protection against mechanical and chemical injury to the conductors. Such protection was urged in 1890 by the National Electric Light Association at the Montreal meeting, and has since been insisted on by the National Board of Fire Underwriters, and still more recently at the conference on the amending of the national code of rules for safe wiring of buildings, held at headquarters of the American Institute of Electrical Engineers in New York, March 20th, 1896. At this conference, the concensus of opinion, which had been emphatically expressed by several delegates of large experience, was tersely summed up by one of the members in the following brief sentences: "The reason for a lining in the interior of iron pipe must be either mechanical or electrical; if it is simply mechanical, it is inexpensive. If the reason is electrical, is it not rather anomalous that, in a city like this, you can have one hundred miles of pipe in the street in which the insulated wires lie in a bare grounded tube, whereas the moment you go into a house you must not have it? These requirements need only intelligent interpretation and enforcement to secure satisfactory results. As there is no outward pressure on conduits for electric uses, the same can be made in a simpler and less costly manner than the metal tubes now marketed, and yet possess all the requisite injury-resisting qualities. As soon as this fact is appreciated by manufacturers, evolution will produce the same beneficial results in respect to lessening the cost of material as was the case with wrought-iron pipe, which has been tremendously cheapened within the past few years through use of improved methods. The adaptability of material to a purpose is well illustrated in the use of iron pipe in the pipe lines from the oil regions to the seaboard, a distance of over 500 miles. These have been in use for many years under enormous pressures, and give perfect satisfaction. On the other hand, all the resources of the United States Government could not provide a masonry conduit that would answer the purposes or stand the tests to which the above mentioned iron-pipe lines are daily subjected.

Professor Silvanus P. Thompson, in his concise and forcible statement made before the Society of Arts on May 5th, 1893, with reference to house wiring, said: "What is wanted is a mode of running the wires and fixing the switches and other accessories, that they shall not only be electric-tight, but shall be water-tight, gas-tight, air-tight, oil-tight, and rat-tight." All of the above requirements, and more, are fulfilled by a properly insulated conductor inclosed in an injury-resisting metal pipe.

In one of the recent installations of one of the large buildings on Broadway, New York, the electrical engineer who made the plans, firmly believing in plain iron pipe, called for it in the specifications submitted to the contractors. The argument used in introducing insulated iron tube, which was afterward installed, was that the insulation did no harm. If this insulation did not cost more than an iron pipe, or a coated iron pipe, that argument might be proper; but the fact is that architects and contractors find it difficult to have their clients agree to this additional expense. If it is not essential, it obviously suggests extravagance in engineering that is not warranted.

It has been said by an eminent engineer: "Proper engineering consists in utilizing no more material than is required to give satisfactory results." Any additional cost may benefit to a large extent those who seek to market their goods at the expense of a business which would have a more rapid growth if unnecessary cost could be avoided. We are all interested in the promotion of what is at once the cheapest and the best.

APPENDIX

"House Wiring for Electric Light." Patent No. 343,087, granted June 1st, 1886, known as Distribution and Control. No suit has ever been brought on this patent, although it has become the standard system of wiring. The company owning the patent has apparently contributed it to public use in order to advance the introduction of its interior conduits.

Extracts from the specification.

"The object in view is to produce a system of wiring houses, vessels or the interior of other structures for incandescent electric lamps, arranged in multiple arc or multiple series, wherein there will be a complete and independent control and protection of all the circuits, so that they can be separately made and broken for turning on and off the lights, and properly inspected and tested for 'grounds,' cross-connections or imperfect insulation or contacts, and so that the danger of injury by the heating of the conductors will be entirely obviated by the protection of both poles of each circuit by fusible safety catches, wherever a smaller conductor branches from a larger one; all this with the smallest possible number of switches and safety catches. The conductors will be of the minimum size and cost, reducing the expense of installation. There will be the minimum number of changes in the size of conductors, so as to simplify greatly the calculations of sizes of conductors and the preparation of proper plans, and to render the work easy of execution by workmen of ordinary intelligence.

"There will be a proper and equal distribution of current upon the conductors and to the lamps, maintaining all the lamps at normal incandescence, practically independent of lamps in other circuits, or divisions of the same circuit, and not taking any conductor unduly or beyond a safe current-carrying limit, and there will be a convenient location of switches and safety catches for the operation of the switches for testing circuits, for repairs and for replacement of safety catches. In general, the system' of house wiring may be stated to be a system of distribution and control, as distinguished from the system of circulation heretofore employed. In the latter system, the main conductors are run past all 'outlets' or points where the wires run into fixtures and the branch lamp circuits are taken from the main conductors at all points along their length, and are run by the shortest paths from the outlets to the mains. The general principle of the system of distribution and control is to take all branch circuits from each pair of main conductors at one point, and, if necessary, to divide a pair of branch conductors to all sub-branches from the branch conductors at one point, and so on, to any extent of sub-division that it may be found desirable to carry the wiring.

"The conductors of each main are protected at the machine or machines or at the street connections (if in a general system,) by double-pole safety catches, and are controlled by switches which are also preferably double pole, and at each point of departure of branch conductors from the mains or of sub-branches from branches, each circuit is protected by a double-pole safety catch, and controlled by a double-pole switch, and the several safety catches and switches for each point of departure of branches from the mains or sub-mains or sub-branches, from branches are assembled together.

"The system heretofore employed has many practical disadvantages and defects, which are overcome and obviated by this system of distribution.

"The features of the invention are applicable to house wiring, whether the wires are concealed or are carried along the surface of walls and ceilings, but while exposed work may be done imperfectly and more expensively by a system of circulation, it is practically impossible to do 'concealed' work in this way. and provide accessible switches and safety catches for all the circuits, and hence the invention has special advantages in its application to concealed work."

A careful study of the patent from which these extracts are quoted may furnish useful information to the electrical engineer.

Extract from a paper read by W. J. Jenks, before the World's Fair Insurance Congress, at the World's Columbian Exposition in 1893:

"It is evident that if conductors are to be capable of ready removal for inspection or replacement, they must be so well insulated from each other and from the tube with which they may be surrounded as to resist the tendency to leakage or short circuit which is produced by the pressure of the particular system to which they are applied. Frequent difficulties arise from the disturbance of such tubes by carpenters, masons, gas-fitters and other mechanics, who make changes in the surroundings after the tubes have been placed. Is there not a suggestion of a cheap and useful form of conduit for this work in the fact that for ten years or more the metal pipes of fixtures carrying electric lamps have supported and mechanically protected the wires by which these lamps have been fed? We have only to consider how the portion of the interior-conduiting system which can be removably inclosed can be extended from the short length, from the lamps back to the service or junction of the interior conductors with the underground or overhead distributing wires, for which extensions of the fixture pipes from the ceiling outlet to the point of supply of the building would provide. Can it not be presumed that if by closing the upper end of the fixture stem with a water-tight plug we have been able for the past ten years to keep the inclosed wires running through that pipe in good condition, so that they have neither short-circuited between themselves nor grounded upon the fixture metal, we can make an entire system of distributing tubes of gas pipes without encountering serious engineering difficulties?"

MR. NICHOLLS: It is unfortunate that Mr. Stieringer, who prepared this paper, is not present; but I presume it would be in order for some delegate to move a vote of thanks to Mr. Stieringer for having taken the time and trouble to prepare such an effective and exhaustive paper.

Mr. Clay moved that a vote of thanks be tendered Mr. Stieringer for his paper.

Mr. De Camp seconded the motion. Carried.

THE PRESIDENT: In the absence of Mr. Stieringer, perhaps we might pass over any discussion of his paper, and proceed with the reading of Mr. Kelly's paper.

Mr. Kelly read the following paper:

SOME ACCOUNT OF THE EVOLUTION OF THE INDUCTOR ALTERNATOR*

In beginning this brief sketch of the evolution of the inductor alternator, I wish to define my conception of the type, and I have found it necessary to include some machines not usually regarded as inductors. An inductor alternator, as I understand it, is one in which the electromotive force in the induced coil is the result, not of changes in the space relations between such coil and the flux-producing agency, but of changes in the flux through said coil, brought about by the motion of iron pieces serving as magnetic conductors. When the flux is due to an exciting coil, the foregoing definition requires constancy of the space relations between the exciting and the induced coils, and in general this constancy of relationship is mechanically expressed by the entire immobility of both coils. It is, however, possible that the inducing coil should turn on its axis without in any way altering its relationship to the induced, and in some cases this is the construction adopted.

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* The almost exclusive reference to English inventors in this paper is not due to underrating the efforts of others, but solely to lack of space and time. It would have been impossible to give adequate recognition to all, and it happened to be more convenient for me to trace the development along English lines until the last stage than along any other. I have no doubt that a parallel history might be written for any of the important cultured lands. At the present time the art of inductor building is more highly developed in the United States and on the European Continent than in England. Indeed, a mere mention of the name of the engineers on the Continent, engaged in the development of inductor machines—Sohlmann, Dobrowolsky, Arnold, Kolben, Brown and Thury—is sufficient evidence that their work must be of importance.

As a means of producing electric energy on a large scale, the inductor alternator is the latest claimant for public favor, and yet it is far from being a new-comer. Its advantages have been apparent from the earliest days of the art, and a long series of distinguished inventors have worked at its development. Although until about eight years ago it was an extremely inefficient generator, its extreme simplicity secured it an introduction when not much power was required. Indeed, if we bear in mind that the Bell telephone, considered as a translating device, is an inductor alternator, we shall have to regard the inductor as the most widely used type of alternator. Our concern here, however, is only with machines useful in large sizes, and any others are of interest only as foreshadowings.

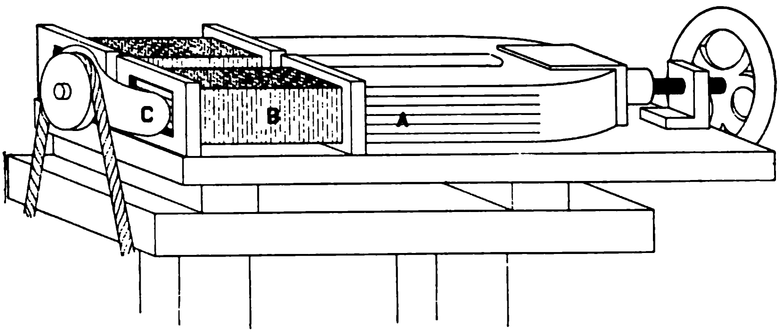

Fig 1

KNIGHT 1854
A INDUCING MAGNET
B INDUCED COILS.
C. ROTATING KEEPER

I shall first call your attention to Knight's machine, shown in Figure 1. This machine was patented in 1854, in England. Its defects are obvious, but it should not be overlooked that it is not worse than its rivals of other types, and, indeed, no worse than most of the modern magnetos for signaling purposes, while it is unquestionably of a more robust construction. Henley's machine, Figures 2 and 2a, consists of an inducing magnet with an electro-magnet set between its poles and in a plane at right angles to them. A double series of rotating keepers connects first one pole of the electro-magnet to the north pole

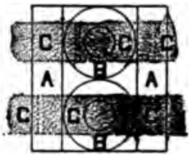

FIG. 2-A.

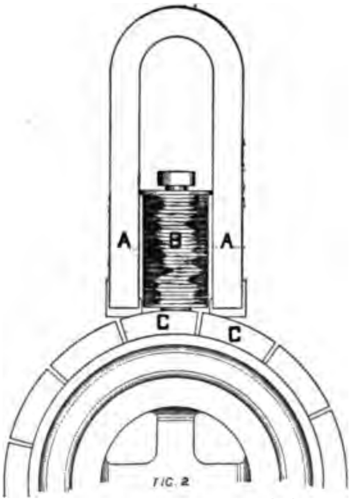

FIG. 2

HENLEY 1856
AA INDUCING MAGNET
BB INDUCED COILS
CC KEEPERS

of the inducing magnet, and the other to the south pole, and then reverses these connections, thus giving use to an alternating flux through the electro-magnet. Figures 3 and 4 show an interesting design of Wheatstone's. There is but a single induced coil, within which moves an iron cylinder provided at each end with radial polar extensions. This single coil form has been taken up again by recent inventors, but has

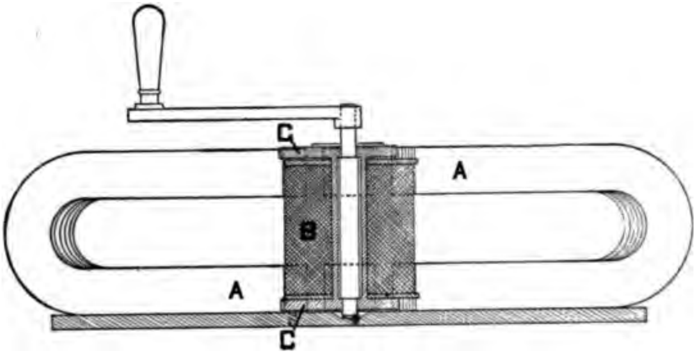

FIG. 3

WHEATSTONE. 1858.
A.A. INDUCING MAGNETS.
B. INDUCED COIL.
C.C. KEEPERS.

not yet come into use. Like Knight's machine, this of Wheatstone's suffers from the great variation in the magnetic flux in the inducing magnets. Wheatstone says that the inducing magnets in this machine may be electro-magnets. Figure 5 shows another design of Wheatstone's, which shows considerable improvement over the other. The variations of magnetic flux are here confined to those portions of the magnetic circuit in which it is necessary they should occur. The flux as a whole is steady, and the machine operates by its varying distribution, the keeper now directing the flux through one pair of induced coils, now through the other. Wheatstone does not appear to have had this reason in mind in duplicating the

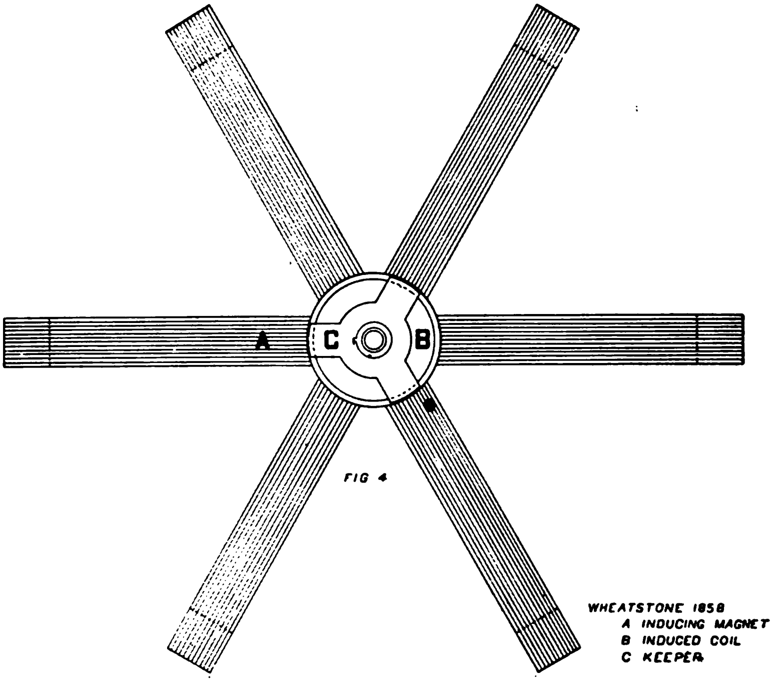

FIG 4

WHEATSTONE 1858
A INDUCING MAGNET
B INDUCED COIL
C KEEPER

induced pair of coils. His object appears to have been to secure a smoother electromotive force curve. This machine was introduced into telegraphy, and I am assured by Mr. Stephen D. Field that it gave first-class service. The Lippens machine, shown in Figure 6, is so like Wheatstone's first design that it needs no description. A machine designed by S. M.

Martin and S. A. Varley is shown in Figures 7 and 8. It consists of two inducing magnets, with an induced magnet between them, connected to the soft iron yoke. A revolving, toothed iron disk alternately closes the magnetic circuits of the two inducing magnets through the induced magnet. This machine may be considered to be Henley's, with one limb of the electro-magnet suppressed, and only one limb of the inducing magnet in action at a time.

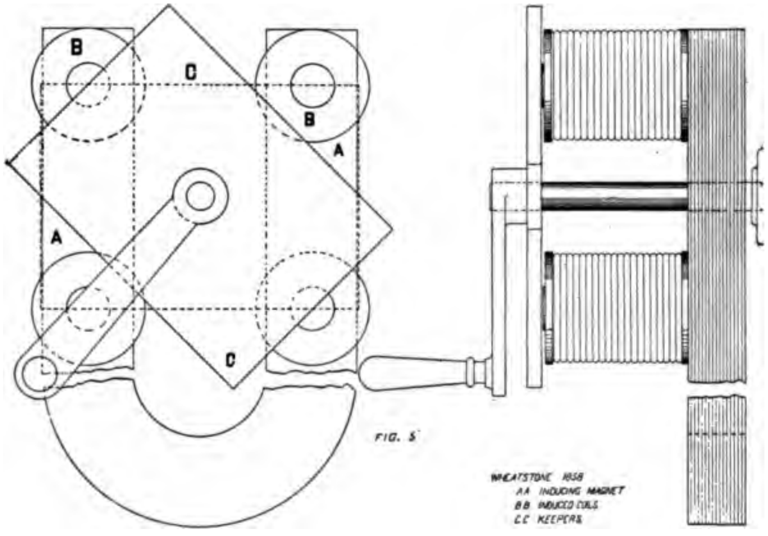
FIG. 5

The machine described by Holmes, Figures 9, 10 and 11, in his English patent of 1868, is worthy of considerable attention. In some respects it may be considered as an inversion of Wheatstone's first design. A single exciting coil gives rise to a number of poles, while the induced electro-magnets are separate and distinct. An interesting feature is that the cores of the induced magnets are slotted to prevent Foucault currents. The exciting coil feature has been adopted in all modern inductors with which I am acquainted, save one, and the sub-division of the iron in armatures to prevent Foucault currents has become a matter of course. Yet, in respect to the steadiness of

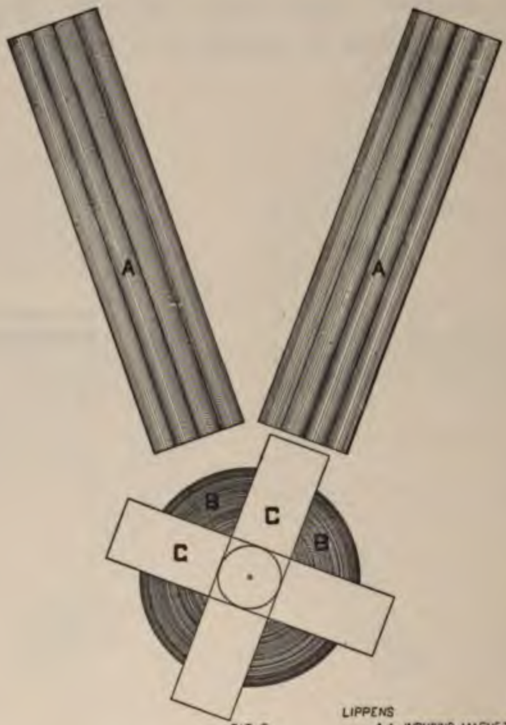

FIG 6

LIPPENS
AA INDUCING MAGNETS
BB INDUCED COILS
CC KEEPERS

the flux, this machine is distinctly retrogressive, and decidedly inferior to Wheatstone's second design. Holmes intended the machine for electric lighting, but I am not aware of its ever having come into practical use.

Gramme's invention came near putting an end to work on inductors, as, indeed, to work on alternators of any kind. Yet, in the time intervening between the introduction of the Gramme machine and the resurgescence of the alternator, provoked by the introduction of the modern transformer, C. F. Varley* designed an inductor, Figures 12 and 13, which deserves mention for its novelty. The induced coils are subject to the influence of two inducing magnets, which tend to develop opposite fluxes through them. These magnets are alternately short-circuited by the keepers, and, in consequence, the flux through the induced coils is alternated by arranging the keepers so that they begin to short-circuit one inducing magnet before entirely open-circuiting the other; the

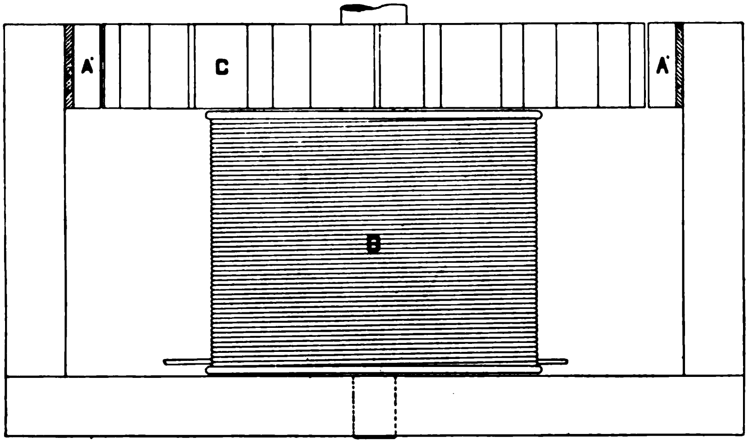

FIG. 7

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* The figures of C. F. Varley's machine were made entirely from description. They may be quite different from those in his patent.

flux in the inducing magnets is kept more or less constant. In this same year, Paul Jablochkoff took out an English patent for an inductor alternator. It is of the single induced-coil type; but were it not for the inventor's great fame, considering the date, it would not be worth attention.

Even the best of these early inductors must have had vast iron losses. In most cases, there was no

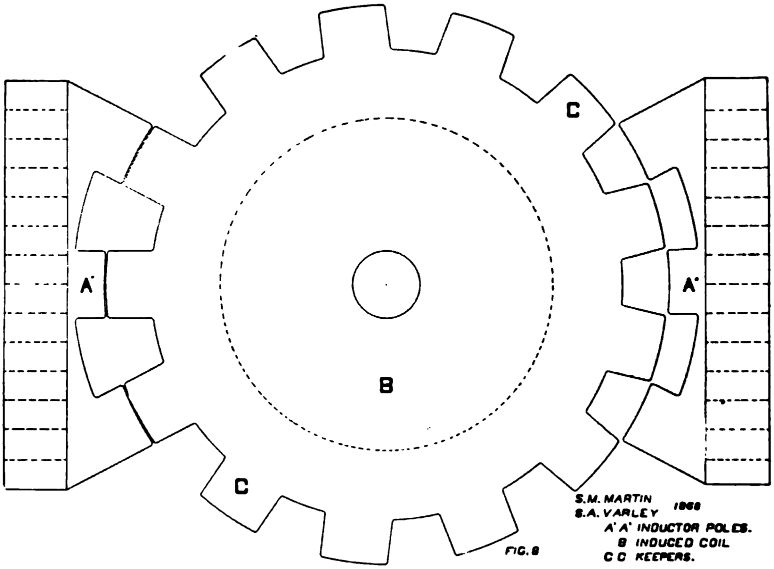
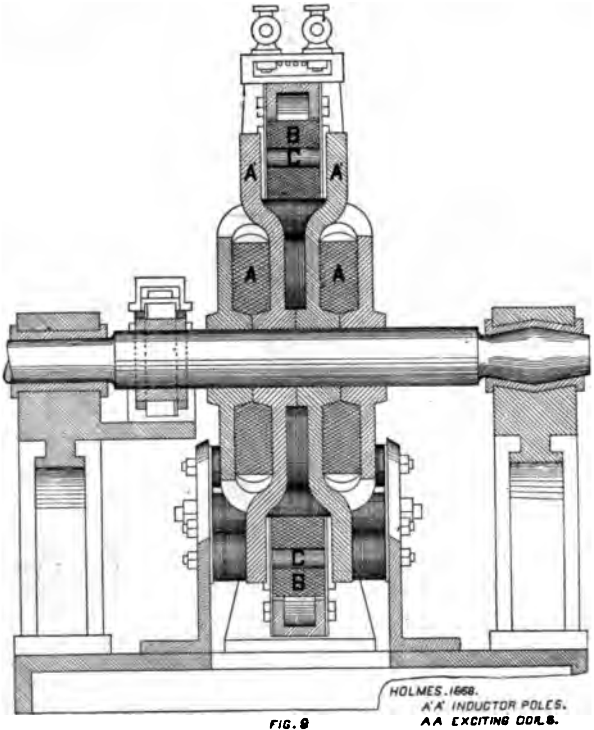


FIG. 8

S.M. MARTIN
S.A. VARLEY 1868
A' A' INDUCTOR POLES.
B INDUCED COIL
C C KEEPERS.

thought of preventing them, and, when preventive measures were adopted, they were entirely inadequate. The mass of iron subject to magnetic change was always, relatively to the size of the machine, enormous, thus necessarily increasing the hysteresis loss; while no sufficient provision appears to have been made for the prevention of Foucault currents. The machine of Klimenko, exhibited at Vienna, which required more power to drive it when running light than when loaded, was not, I think, exceptional.

In 1887, Mordey cut the Gordian knot by entirely suppressing the iron in the induced portion of the machine. The highly and deservedly successful



HOLMES. 1868.
A'A' INDUCTOR POLES.
AA EXCITING COILS.
BB INDUCED COILS.
CC KEEPERS.

FIG. 8

machine that bears his name, is shown in Figures 15 and 16.

There is a central core surrounded by the exciting coil A. From each end of this core projects a set of radial polar arms, which are recurved so as almost to meet one another. In the space left free are mounted the thin induced coils BB in a circle. The induced coils are wound in the plane of this circle and are in number twice the polar faces on one side. The induced coils are fixed and the inducing magnet revolves. The exiting coil turns with the core, but this is electrically immaterial, and the results would be the same were it at rest. Obviously, the total reluctance of the magnetic circuit is the same, no matter what the position of the inductor. Change of flux in the iron is due only to armature reaction, and it gives rise to iron losses only because of its space variations. With a low armature reaction, such losses will be extremely small.

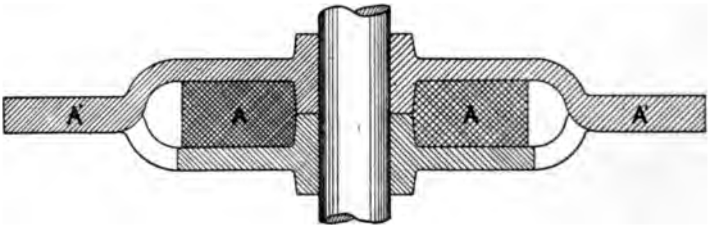


FIG. 10

HOLMES. 1868
A'A': INDUCTOR POLES.
AA. EXCITING COIL.

Mordey's success, instead of putting an end to attempts to build inductors with iron in the induced portions, gave rise to a new series of efforts. Indeed, Mordey himself was foremost. His English patent of 1887, relating to the coreless armature machine, also described a machine with cores, and in subsequent patents he describes the machines shown in Figures 17, 18, 19 and 20.

These machines have not come into use, and, presumably, they are not as satisfactory as the coreless machine. Yet they show a marked advance when compared with the older machines. The use of the

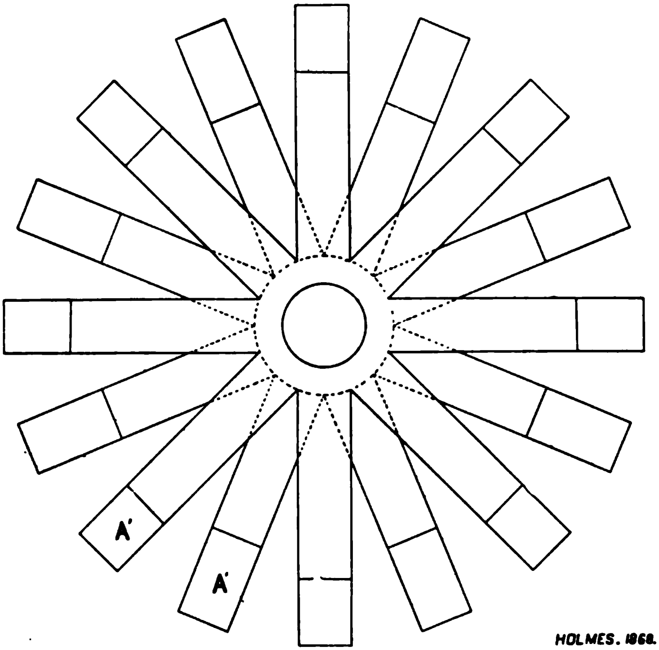


FIG. 11

HOLMES. 1868.
A.A'. INDUCTOR POLES.

short-circuiting pieces C', as well as the bridges C, tends to make the flux constant in amount and to restrict the magnetic changes to the induced portions of the machine. The iron subject to magnetic change is also properly laminated to prevent Foucault currents. The most obvious fault in the designs is that the mass of iron in the induced portions is large, and that all of it is subject to hysteresis loss.

In passing, it may be worth while to note one peculiarity of single induced coil machines like the earlier of the Mordey designs. With any given frequency, the output is independent of the speed; or, in other words, the only limit to reduction of speed is the possibility of further sub-dividing the poles. For, with the number of poles increased N times, the total change of flux takes place with 1/Nth the angular motion. This remarkable property may some day bring about the introduction of machines of this class for direct connection to very slow-speed engines.

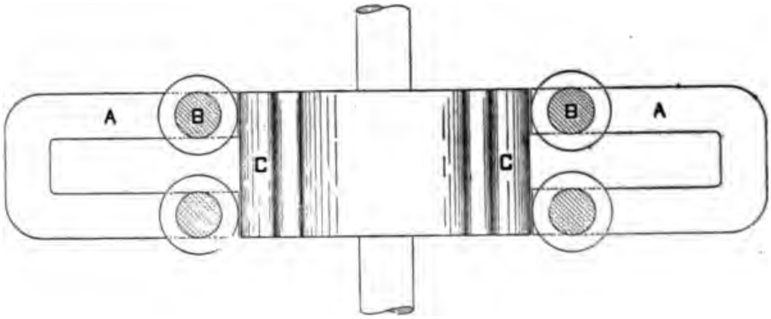


FIG. 12

C.F. VARLEY. 1877.
A.A. INDUCING MAGNETS.
B.B. INDUCED COILS.
C C KEEPERS.

The Kingdon machine, Figure 21, is a modernized Henley machine. The exciting and induced coils are wound on the alternate polar projections, and the magnetic connections between the inducing and induced cores are alternately reversed by the rotating keepers C. The whole of the iron in the machine appears to be subject to hysteresis loss. Foucault currents are checked in the usual manner by lamination. In this machine, if the induced coils are so wound that they may be worked in parallel, it is possible to reduce the iron losses in proportion to the load by cutting out both inducing and induced coils in the same degree. I hardly think that this advantage is sufficient to countervail having the hysteresis loss too high to begin with. A few of these machines were put into practical use, but I think not many.

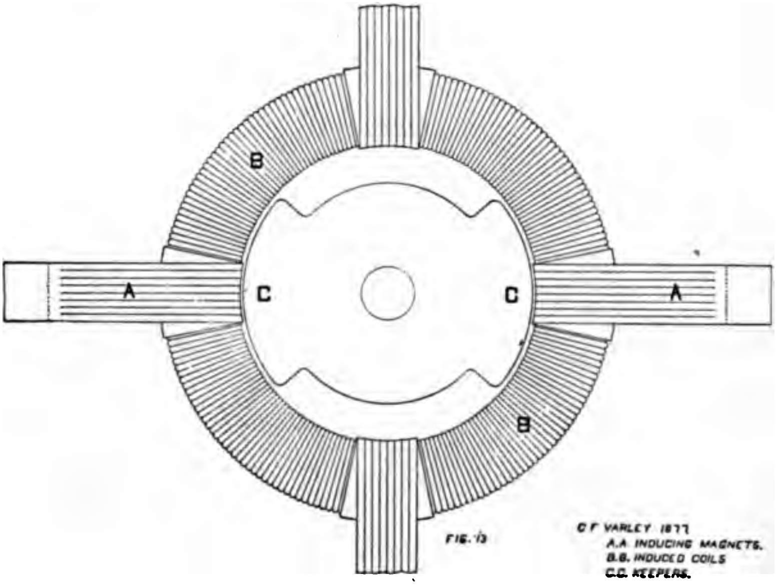


FIG. 13

C F VARLEY 1877
A.A. INDUCING MAGNETS.
B.B. INDUCED COILS
C.C. KEEPERS.

The machine designed by Rankin Kennedy in 1890 is a twinned form of the Mordey, shown in Figures 17 and 18, with the short-circuiting pieces C′ left out. This necessitates the lamination of the whole of the iron, and subjects it all to hysteresis loss. The twins are so arranged that the induced electromotive forces in the inducing coils are in opposition, so as to prevent the development of alternating currents in the inducing circuit. The machine has not, I think, been practically introduced, and, in my judgment, it is less fitted for use than its prototype.

The modern machines thus far described lend themselves badly to polyphase working. This is true even of the standard Mordey, while as to the others, adaptation to polyphase means practically duplication or triplication of the whole machine. As polyphase machines, they are merely mechanical combinations of single-phase machines. A machine adapted directly to polyphase working, on the other hand, regulates

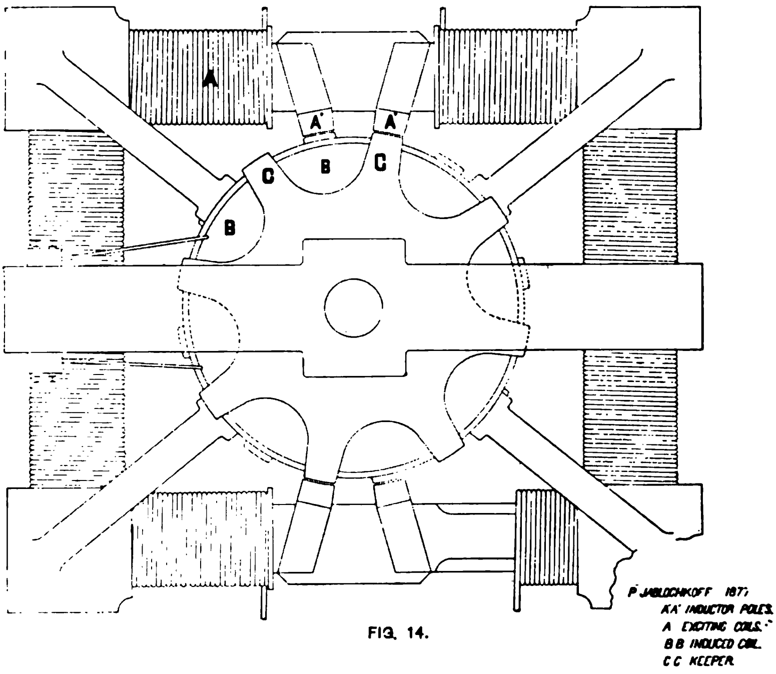


FIG. 14.

more closely, and is more efficient as a polyphase than as a single-phase machine. The machines that follow are all suitable for polyphase.

The first of them, Figures 22 and 23, is due to one of the masters of our profession in this country,

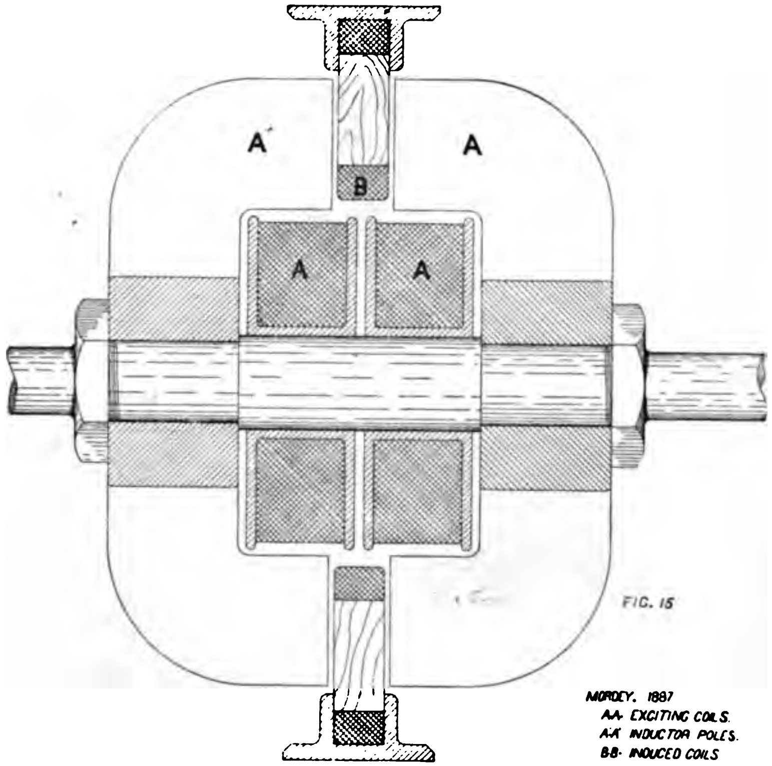


FIG. 15

MORDEY. 1887
AA. EXCITING COILS.
A'A' INDUCTOR POLES.
BB. INDUCED COILS

and would even on this account alone be worthy of attention. But mechanically, in the robustness and simplicity of design, it seems well in advance of its predecessors. The induced coils are well secured and out of harm's way, and the only moving pieces in the machine are the shaft and the single star-shaped inductor. The adaptation of the machine to single, two or three-phase working is merely a matter of the number and grouping of the induced coils. The duplication of the exciting coil is not, I think, to be considered an improvement. High hopes were entertained of the future of this machine. Of the causes of their frustration it is not for me to speak.

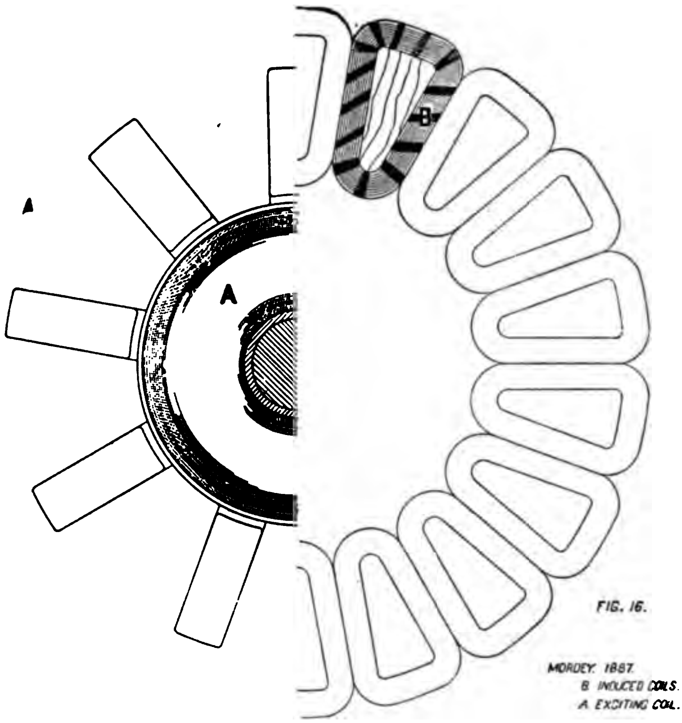


FIG. 16.

MORDEY. 1887.
B INDUCED COILS.
A EXCITING COIL.

The operation of the Pyke and Harris machine will be clear from the drawings, Figures 24 and 25. The machine consists of a pot magnet with a central core. At the bottom of the pot lies the inducing coil A. The lip of the pot and the core carry inwardly and outwardly projecting laminated polar extensions which support the induced coils B. Between these polar extensions move the rotary laminated keepers C. What I have called keepers here, on account of their appearance and size, really correspond to the inductor in the Thomson machine, and in that which follows, for they normally constitute that portion of the machine in which the flux is most invariable. There is no reason why a machine of this form should not be all right electrically if well designed. Mechanically, however, it seems to sacrifice that very simplicity which makes inductors desirable.

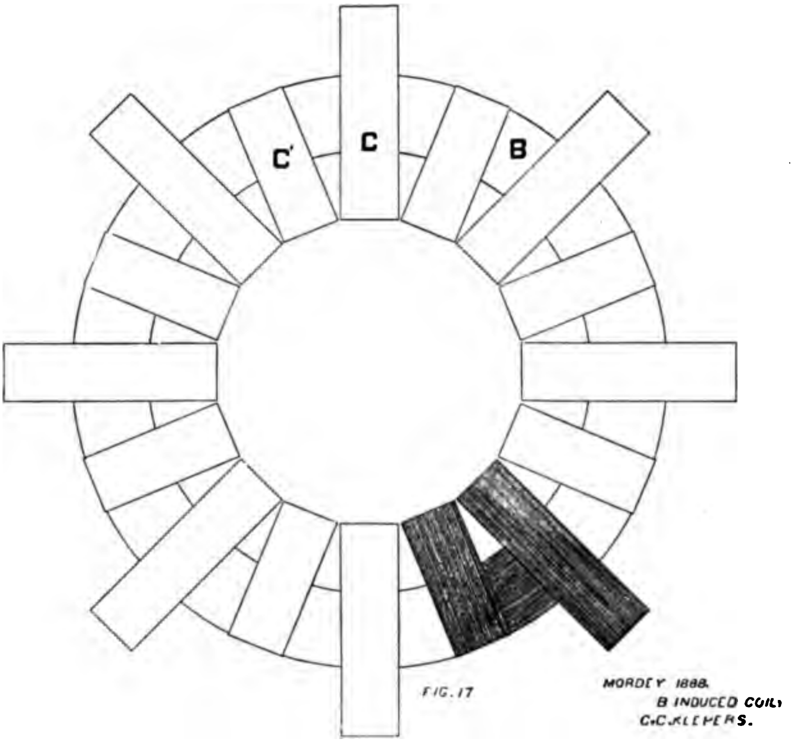


FIG. 17

I now come to the machine with which I am best acquainted, and in whose designing I took part. For these reasons I may be pardoned for going more into detail in the description, since they enable me to give more information. Coming after that of so many able engineers, it is scarcely to be expected that the work of my colleagues and myself should result in any startling change in form, and, in fact, our improvements are not such as to catch the eye. They, however, have made the induction alternator with iron-cored armature a success; so much so, that I have no hesitation in saying that the inductor is

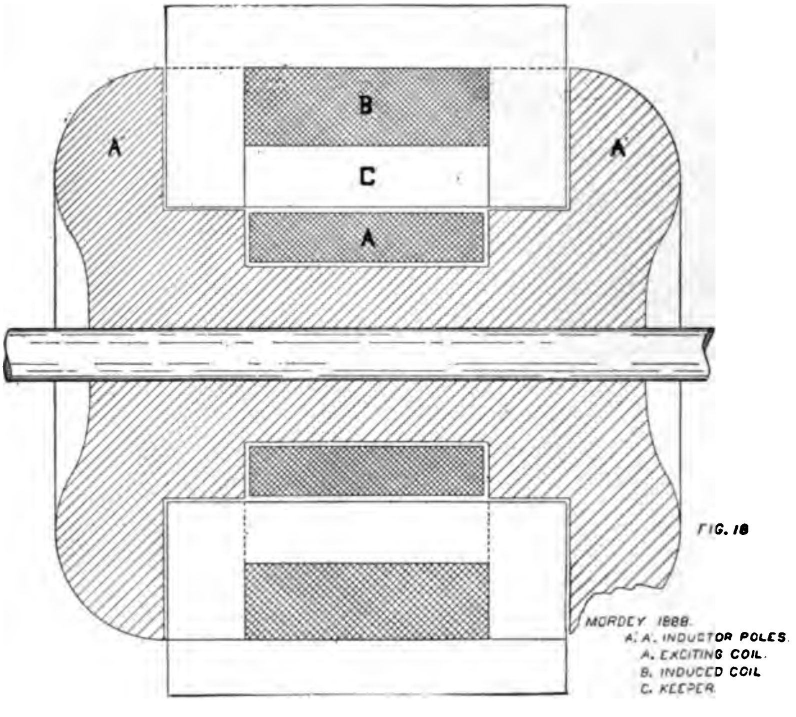


FIG. 18

not only the alternator of to-morrow, but that it is the alternator of to-day.

Figures 26 and 27 show clearly the construction of the machine. The rotary inductor is a cylindrical steel casting with outwardly projecting, laminated pole-pieces at either end. The armature consists of two rings connected by wrought-iron tie bars. The induced coils are sunk below the surface in grooves in the armature rings, and the stationary exciting coil lies in the space between the pole-pieces and the armature rings. The machine is very effectively ventilated by means of openings in the middle of the

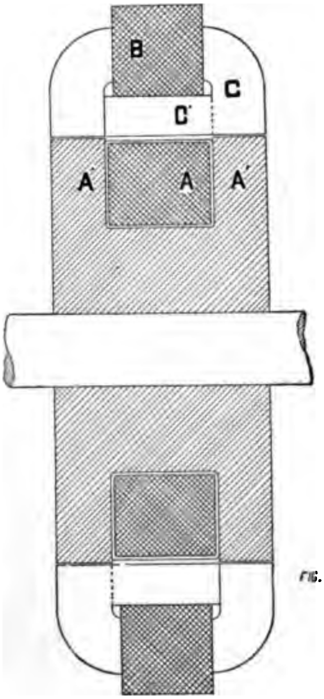


FIG. 19

MORDEY 1889
A EXCITING COIL.
A'A' INDUCTOR POLES.
B INDUCED COILS.
CC' KEEPERS.

inductor under the exciting coil and the spaces between the tie bars. The exciting coil itself is protected from injury by a massive hollow ring of cast copper, inside which it is wound.

I have already called attention to the importance of keeping the flux constant in the inductor, so as to avoid hysteresis and Foucault-current losses therein. The only thing tending to disturb the inductor flux is the varying reluctance caused by change in the relative position of the armature slots and the inductor poles. To keep this at a minimum, is the chief reason for preferring a double wreath of induced coils to a single one. Mechanical interruption at both ends is

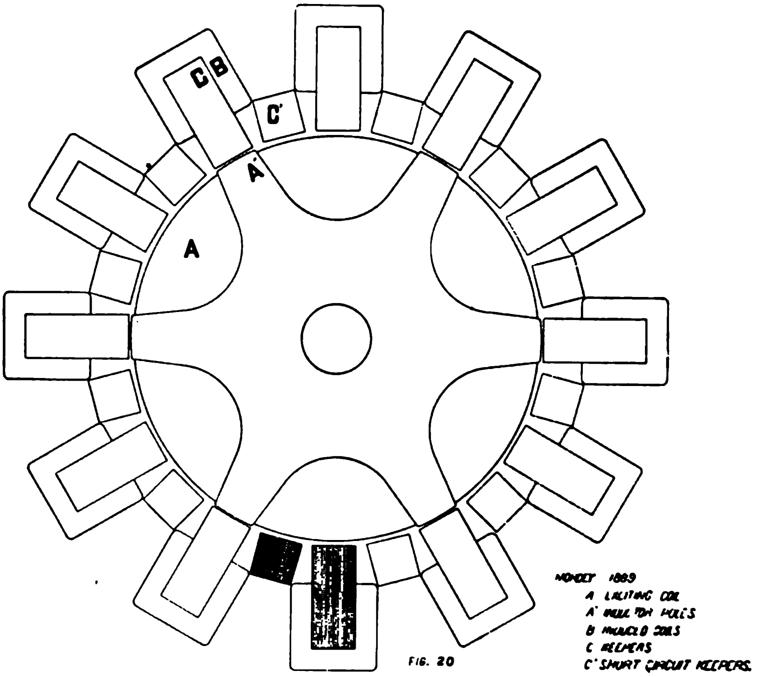
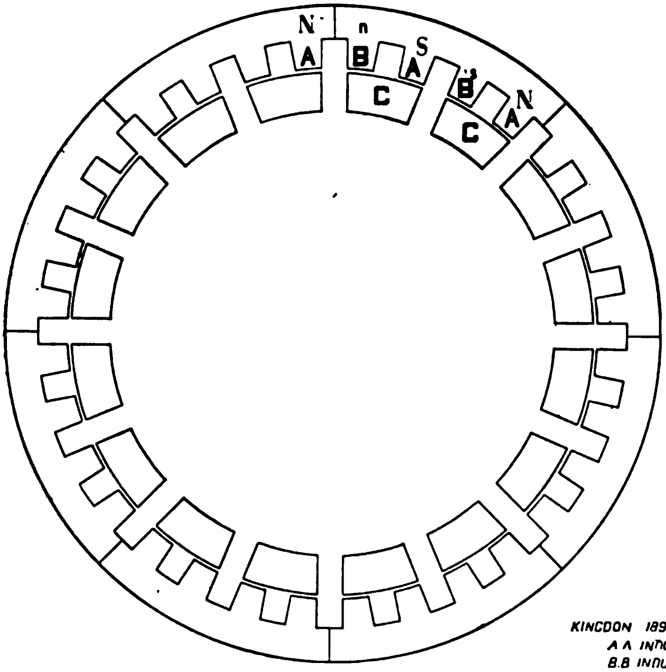


FIG. 20

necessary in either case, and it is wise to take advantage of it in distributing the induced coils. With the same amount of wire, the space variation of reluctance is much less when both air-gaps are utilized than when only one is, and, at the same time, the regulation of the machine is better. As complete lamination of the body of the inductor is difficult, even a slight change of flux is to be sedulously avoided. Lamination of the pole-pieces is necessary, even with constant flux, as the slots necessarily change its distribution.



KINGDON 1891
A A INDUCTORS
B.B INDUCED CORES.
CC KEEPERS.

FIG 21

But, even with the flux through the inductor constant, the difficulties are by no means surmounted.

A large mass of iron in the armature is a necessity of the construction, and the losses in this way may be such as to make the machines practically inoperative. Only thorough lamination would put an end to the Foucault losses, and thorough lamination is, for structural reasons, out of the question. Another solution is imposed. Now, when the flux is constant in the inductor, it is obvious that in amount it must also be constant in the armature. It but shifts in position without altering in magnitude. But to give rise to the electromotive force in the induced coils, it is unnecessary that the shift should take place throughout the mass of the armature. It is necessary only that the shift should take place through the coils; that is, to the depth to which the coils are embedded. The problem is, therefore, to combine a

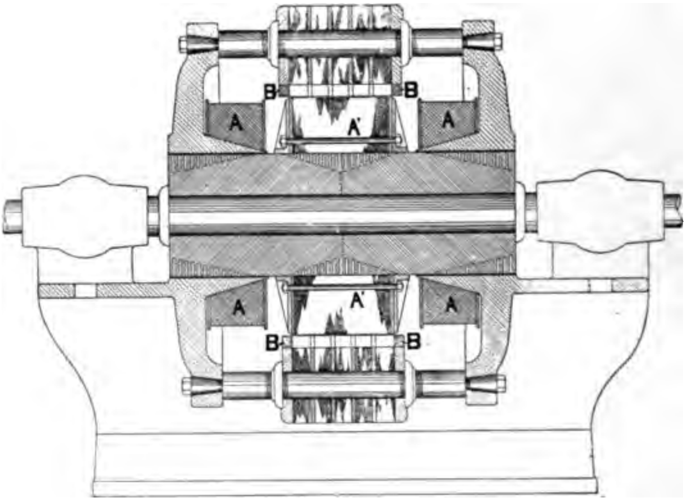


FIG. 22

THOMSON 1890
A' A' INDUCTOR POLES.
A A EXCITING COILS.
B B INDUCED COILS.

steady flux in the center of the armature with a shifting flux in the armature faces; or, in other words, the distribution of the flux in the middle of the armature must be independent of the points in the faces at which the flux enters. Stated in this way, an analogy with the conditions of electrical distribution in parallel is suggested, and this points to the solution. Consider for a moment the two laminated rings as electrical mains and the tie bars as translating devices. Then, if the two mains be of low and the translating devices of high resistance, the current through the translating devices will be substantially

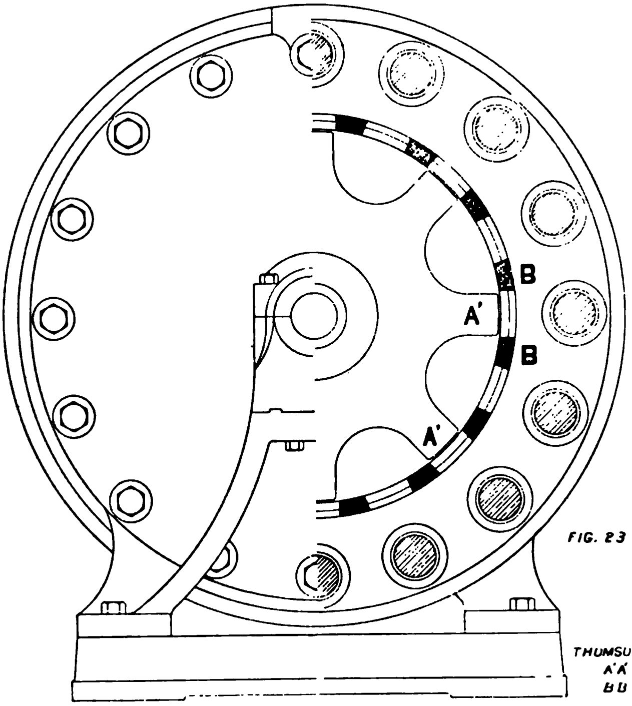


FIG. 23

THOMSON 1890
A'A' INDUCTOR POLES.
BB INDUCED COILS.

independent of the points of attachment of the feeders —the analogues of the inductor poles. Similarly, if the reluctance in the direction of the lamination be low in comparison with that in the direction of the tie bars, the magnetic flux in each bar will be constant, no matter what the position of the inductor poles. In this manner, the change of flux is confined

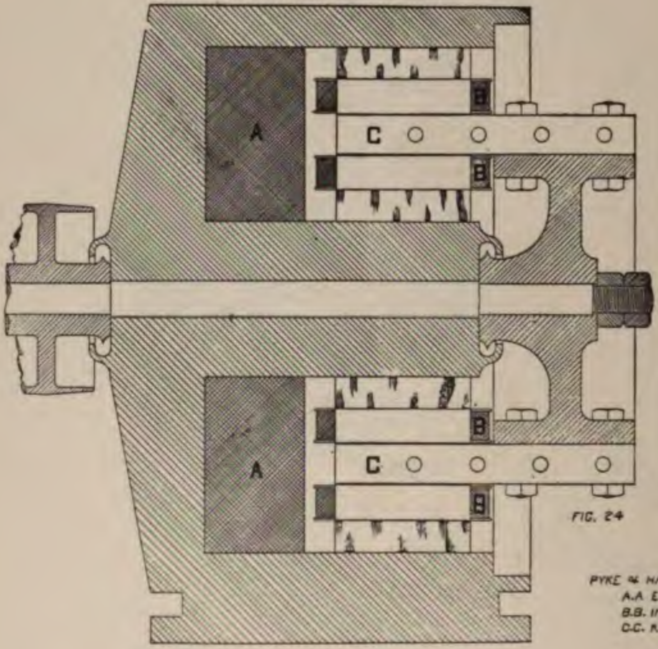


FIG. 24

PYKE & HARRIS, 1892.
A.A EXCITING COILS.
B.B. INDUCED COILS.
C.C. HELPERS.

to a small portion of the armature iron, which may be thoroughly laminated, and thus Foucault-current losses are suppressed and hysteresis losses reduced to a minimum. It thus becomes possible to use in the armature any quantity and form of iron demanded for structural reasons.

It will be noticed that the inductor poles are curved in a special manner. This is done to make the electromotive force curve as nearly as possible a sine curve. You will remember that some time ago much space was given up in the electrical journals to a controversy as to the best form of electromotive force wave. Nearly every form of wave found some advocate for some purpose, but somehow the sine wave seemed always to be second best. As we are building machines for general service, we are entirely

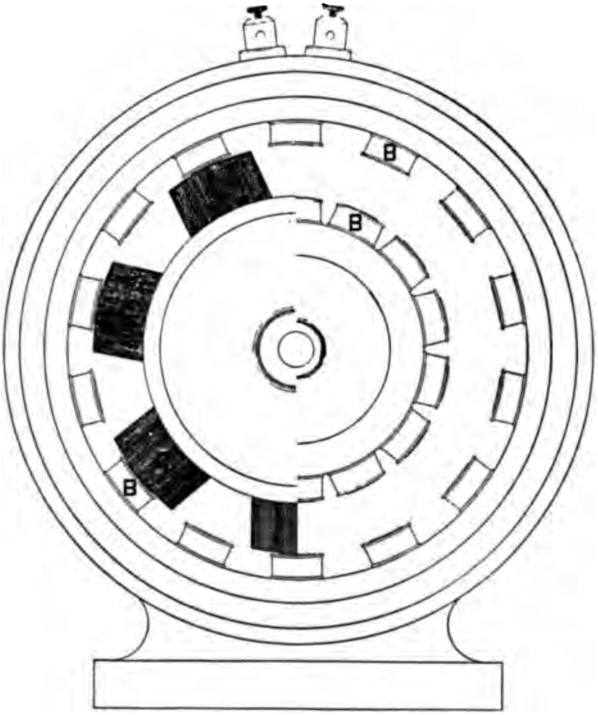


FIG. 25

PYKE & HARRIS. 1902.
B.B. INDUCT'D CIRS.
C.C. VETMIS.

satisfied with that curve which is second best for each special purpose, believing it to be in consequence the best for general distribution work.

The heavy copper bobbin surrounding the exciting coil, besides being a mechanical protection for the coil, is also of use in that it prevents the development of an excessive electromotive force in either exciting or induced coils, if the exciting circuit should be accidentally broken. It resists very powerfully any sudden change of flux.

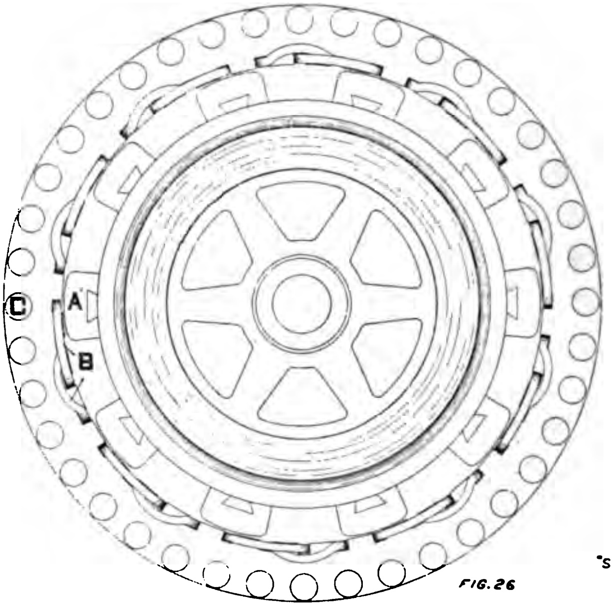


FIG. 26

"S K C" 1893
A INDUCTOR POLES
B INDUCED COILS
C KEEPERS.

An important advantage of all stationary induced-coil machines, and, of course, therefore, of inductors, is the possibility of regulating separate circuits or feeders with little or no auxiliary apparatus. Since it is possible to tap the armature coils at any point, any desired electromotive force between zero and the maximum may be obtained for one circuit without altering the excitation, and, consequently, without interfering with the electromotive force of any other circuit. Circuits or feeders having different drops may thus be provided for. Figures 28 and 29 show two methods of operation. The coils AA in the first

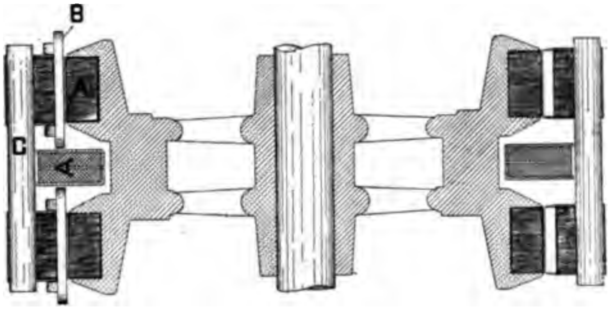


FIG 27

"SKC" 1893
A EXCITING COIL
A' INDUCTOR POLES
B INDUCED COILS.
C KEEPERS.

are the main inducing coils, giving the electromotive force necessary for all circuits or for the mains in a feeder and main system. BB are the auxiliary or regulating coils. The number of the regulating coils in circuit is controlled by the switches CC. The diagram shows only two circuits; but, of course, any number may be branched on, each with its own regulating switch. This method is the simpler for the operation of only one or two machines. With a larger number of machines I would recommend the method shown in Figure 29, as it gives simpler switch connections. In this method, the auxiliary induced

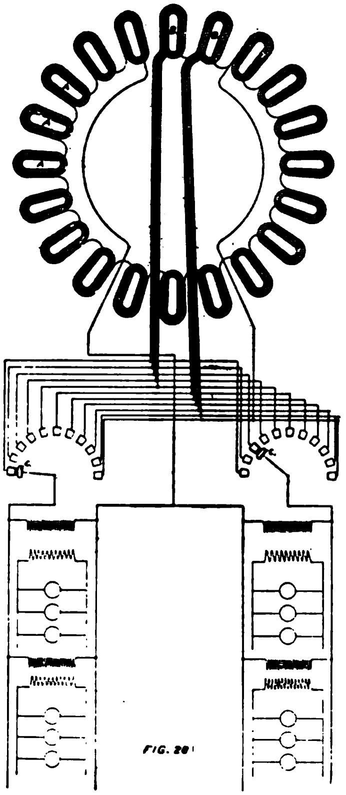


FIG. 28

coils do not act directly upon the circuits, but only through the intermediary of the auto-converters D. This method of regulation has the advantage over the ordinary "booster" system that the auto-converter D has, for the same regulation needs to be only one-half the size of the corresponding "booster," and it is, besides, more efficient. The adoption of either method secures the same flexibility and ease of control of the individual circuits as if a separate machine were used to feed each one, while, at the same time, we get the lower first cost and greater economy of operation of large machines.

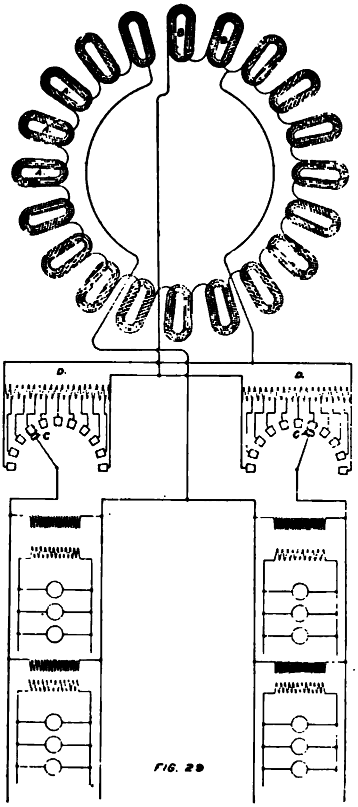


FIG. 29

DISCUSSION

THE PRESIDENT: Gentlemen, we have heard a very interesting paper by Mr. Kelly, and I should be glad to hear from members of the association who desire to ask any questions or to discuss the propositions suggested in his paper. I should like to hear from Dr. Bell upon that subject, if he is present.

DR. BELL: Mr. President, I have been very much interested in Mr. Kelly's paper, as giving a peculiarly effective resumé of the work that has been done on this very simple machine. It is a type that has only recently come into extensive use, in spite of the fact of its having been one of the first devised, as Mr. Kelly has shown. It would be easy to go on and show a vast number of other possible forms of the inductor dynamo. Of course, one might readily devise inductor forms similar to almost every form of field magnet for ordinary machines, but that would hardly lead to any more valuable results than have already been obtained.

Perhaps the reference that most interested me in Mr. Kelly's paper, was that to the sine wave controversy. The sine wave controversy was bitterly waged, for some little time, through the medium of the journals, and, as nearly as I have been able to figure, the position taken by those interested in the development of machines that give particular forms of wave, was that the form of wave given by their machine was the only form of wave that the public wanted.

It is a little hard to sum up a controversy of that kind, but there is one point I should like to throw out as the probable explanation of the very discordant results that were reported, and that is this: We find, oftentimes, that alternators do not give waves that are anywhere near approximate to sine curves. The discordance may always be accounted for by the presence of harmonic electromotive forces. These may be considered as superinduced on a fundamental sine form, giving the distorted waves with which we are decidedly familiar in actual practice. Now, it has been pointed out by some investigators—and very good ones—that, singularly enough, this distorted wave is capable of giving better results with static transformers—slightly better efficiency—than a sine wave of the same frequency. If you stop to consider a moment, you will see that, given a machine that has a distorted wave, due to the presence of harmonic electromotive forces, you have in the transformation of energy from that machine a certain amount of energy—and by far the largest amount—transformed at the fundamental frequency; with, at the same time, other amounts, smaller and varying in magnitude, transformed at a frequency of three, five, seven, nine, etc., times the fundamental frequency. Hence, the net result may be, under certain circumstances—and I doubt not is in the case of certain static transformed phenomena—that the average frequency of the alternator having harmonic electromotive forces is practically higher in actual working than the frequency of its fundamental. In other words, the effect on the transformer is very closely similar to that which would be obtained by taking an alternator that gives nearly a true sine wave, and slightly raising the frequency. In other words still, if we have an alternator giving a wide departure from the sine wave, we may consider that that alternator has an equivalent frequency, with respect to the transformation of energy from it, a little higher than its nominal frequency. This would account for the results that have been obtained by static transformers showing under similar circumstances slightly better results.

With induction motors, nearly all experimenters seem agreed that what difference there is between the alternators having a sine wave and those that have not a sine wave, is in favor of the former. Most experimenters have found that the induction motors are apt to run a little better with an alternator that gives a sine wave, and this fact is easily explicable on the same principle of harmonic frequencies that explained the facts in regard to static transformers. If you have a motor designed to run at a particular frequency, and thrust upon it a machine that delivers part of its energy at the frequency for which the motor was designed, and part of its energy at some other frequency, the result naturally is that the energy delivered at the higher frequency does not work so effectively in that particular motor as that delivered at the frequency for which the motor was built. Hence, as a rule, slightly worse results from a widely distorted wave.

I think this simple point of view explains, partially, at least, nearly all the discrepancies that have been found between experiments tried on static and on rotating transformers—for such induction motors are —with current waves of different forms. Of course, it quite goes without saying, that if you have a motor running on a distorted wave circuit, but so designed that its own distorted waves are the same as those received from the circuit, you may then be able to obtain a motor that will run just as well, and perhaps a little better, on the machine giving its own form of wave than it will on others.

THE PRESIDENT: Are there any further remarks upon this paper? If not, we will proceed to the reading of the report of the Committee on Rules for Safe Wiring.

Mr. W. J. Hammer read the following report:

REPORT OF COMMITTEE ON STANDARD RULES FOR ELECTRICAL CONSTRUCTION AND OPERATION

Mr. President and Gentlemen:

Since your committee presented its last report, a large number of meetings have been held and the work entrusted to them actively prosecuted. With a view of showing the character of this work and the results thus far achieved, we have embodied in this report certain documents which have been prepared by your committee in carrying out their instructions and in the furtherance of the aims and objects of this association. The first matter that we present is the preamble and resolutions sent out by the committee September, 1895, which read as follows:

Preamble and Resolutions Adopted by the Committee on Standard Rules for Electrical Construction and Operation of the National Electric Light Association.

SEPTEMBER, 1895

PREAMBLE

Whereas, There exists at present a diversity of rules relating to the installation and use of wires for various electrical purposes, and whereas this diversity of rules and the varied interpretations placed upon the same unquestionably hamper the general enforcement of such rules, and whereas the time has now arrived when to secure a proper uniformity of, and general observance of, one standard set of rules, a vigorous and concerted action by the various branches of the electrical, insurance and allied industries is of paramount importance; it is hereby

Resolved: 1st. That the undersigned Committee of the National Electric Light Association upon Standard Rules for Electrical Construction and Operation, acting in behalf and by direction of said association, do hereby extend a most cordial invitation to the hereinafter mentioned organizations to unite with them in the forming of a joint committee to undertake the codification, promulgation and enforcement of one standard set of rules which shall meet as fully as possible the conditions that now exist and be acceptable to all electrical, insurance and allied interests.

Resolved: 2d. That in view of the very large number of electrical, insurance and other boards, companies, societies and associations, as well as individual consulting engineers and experts, who are manifestly interested in, and affected by, work of the character proposed by said joint committee, and as it will be impracticable to invite all such organizations or individuals to co-operate, it is deemed advisable to limit the invitation to national organizations and companies that are practically national in the scope and character of their work.

Resolved: 3d. That, in order that the committee may not be too unwieldy, and in view of the considerable number of organizations whom it is deemed advisable to invite to co-operate with our committee, each organization be requested to send one representative with full power to act for that organization in the preparation of the joint report, and which delegate shall present said joint report to his organization for final approval and adoption by that body.

Resolved: 4th. That the proposed invitations be extended to the following organizations, accompanied by a copy of these resolutions:

American Institute of Electrical Engineers
American Street Railway Association
National Board of Fire Underwriters
American Institute of Architects
International Fire Chiefs' Association
American Bell Telephone Company
Western Union Telegraph Company
Postal Telegraph Company
General Electric Company
Westinghouse Electric and Manufacturing Company

Resolved: 5th. That the proposed joint meeting shall be held in the city of New York, on the date of January 15th, 1896.

Resolved: 6th. That the place of meeting shall be hereafter determined and due notice sent to all interested parties.

Resolved: 7th. That a copy of these Resolutions be sent to the Electrotechnical, Insurance, Architectural and Fire Press, together with a hearty invitation to all persons interested in this important work, to send to the committee, prior to the joint meeting, such criticisms and suggestions as shall be of value in the consideration of rules now in vogue, and render more complete, thorough and up-to-date the proposed Standard Set of Rules.

WILLIAM J. HAMMER, Chairman,
JAS. I. AYER,
HARRISON J. SMITH,
E. A. LESLIE,
WM. BROPHY,
Committee.

The date of the meeting of the conference was subsequently changed to March 18 and 19, 1896, when the following organizations were represented, and in the appended list are given the names of the delegates appointed to represent those various organizations; and the character of the appointments made was in every case so high as to guarantee a most careful consideration of the important questions to come up and their treatment in an able and conservative manner. The list of those who were invited to co-operate with your committee, together with their delegates, is as follows: American Institute of Electrical Engineers, Professor Francis B. Crocker, Columbia College, New York; American Street Railway Association, Frank R. Ford, Consulting Electrical Engineer; National Board of Fire Underwriters, William H. Merrill, Chief Electrician. Chicago, Ill.; Western Union Telegraph Company, A. S. Brown, Chief Electrician, New York; Postal-Telegraph Company, Francis W. Jones, Chief Electrician, New York; American Institute of Architects, Alfred Stone, Secretary, Providence, R. I.; National Association of Fire Engineers, Morris W. Mead, Superintendent Bureau of Electricity, Pittsburg, Pa.; American Bell Telephone, C. J. H. Woodbury, of the Engineering Staff, Boston, Mass.; General Electric Company, Lieut. S. D. Greene, General Manager Lighting Department, New York; Westinghouse Electric and Manufacturing Company, Charles F. Scott, Electrician, Pittsburg Pa.; The Associated Factory Mutual Insurance Association, E. V. French, Electrical Inspector, and the Underwriters' National Electric Association, E. A. Fitzgerald, Electrical Inspector; the National Electric Light Association was represented by the committee that has had charge of the standard rules of that association for a number of years, and who have taken the initiative in the forming of the joint committee; they are as follows: William J. Hammer, Chairman, Consulting Electrical Engineer, New York; James I. Ayer, Consulting Electrical Engineer, Boston, Mass.; Harrison J. Smith, General Operating Superintendent Edison Electric Illuminating Company, New York; E. A. Leslie, Vice-President and General Manager Manhattan Electric Light Company, New York City; Captain William Brophy, Electrical Expert of the Commissioner of Wires of the City of Boston, Mass.

In addition to the above official delegates, the following complimentary delegates were invited to the joint conference in an advisory capacity; but solely as individuals and not representing any association, or manufacturing interest: William McDevitt, Inspector Board of Fire Underwriters, Philadelphia, Pa.; A. E. Kennelly, Consulting Engineer and Expert, New York; W. J. Jenks, Electrical Engineer and Expert, New York; A. H. Henderson, Chief Inspector Fire Department, New York; Morris W. Mead, Superintendent Bureau of Electricity, Pittsburg; Professor William A. Anthony, Consulting Engineer; S. E. Barton, New York.

The following visitors were also in attendance: C. H. Wilmerding, President of the National Electric Light Association, Mr. Halloway, late President of the American Society Mechanical Engineers; Professor Hutton, Secretary of the American Society of Mechanical Engineers, and others.

Upon motion, William J. Hammer was made permanent president of the conference and C. J. H. Woodbury, secretary. Upon invitation of President Hammer, Mr. C. H. Wilmerding then addressed the meeting in a few well-chosen remarks. He hoped that the various interests represented would agree upon a uniform code, and further suggested that, in order to make their work permanent and keep up with changes which experience or changing methods found necessary, the organization as assembled should be made permanent. Upon motion, a committee was appointed to consider the question of permanent organization, namely; Alfred Stone, Francis B. Crocker, William Brophy, William H. Merrill, S. D. Greene, C. J. H. Woodbury. The following committees were also appointed: By-Laws, Crocker, Merrill, Brophy; Wiring Rules, Crocker, Ford, Merrill, Stone, Fitzgerald, Brophy, French, and the president a member ex-officio. The committee on permanent organization later reported unanimously in favor of such a plan, and that only national bodies be represented, but that manufacturing or supply companies might be admitted as associate delegates without the right to vote; the organization also to have the right to avail itself of the advice or experience of experts in their various capacities.

The report was adopted, and the secretary instructed to extend to other national bodies, not now represented, an invitation to send representatives to future conferences.

Under this decision, future conferences will be composed as follows, if the invitations are all accepted:

National Electric Light Association, American Institute of Electrical Engineers, American Street Railway Association, National Board of Fire Underwriters, American Institute of Architects, National Association of Fire Engineers, Underwriters' National Electric Association, Factory Mutual Insurance Association.

Invited: American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, American Society of Naval Architects and Marine Engineers, National Master Builders' Association.

Associate Members: Western Union Telegraph Company, Postal Telegraph Company, American Bell Telephone Company, Westinghouse Company, General Electric Company, and others.

Through the courtesy of the American Society of Mechanical Engineers, the building at No. 12 West Thirty-first street, New York City, was made permanent headquarters, where communications of interest to the committees or conference can be addressed.

Captain Brophy, by request of your committee, had prepared and now read a paper on the history of attempts at formulating standard rules by the National Electric Light Association and others, and your committee respectfully suggest that this paper be printed as accompanying this report, believing a record should thus be made of the important part played in the past by this association.

Your committee also submitted to the conference, as a basis for the discussion, a pamphlet containing the codes of rules that are largely in vogue in this country and abroad, emanating from the following organizations: National Electric Light Association, National Board of Fire Underwriters, Associated Factory Mutual Insurance Companies, Phœnix Fire Insurance Company (English) and Board of Trade (English). Various other matters relative to American and foreign practice were presented at the conference, and after a most earnest consideration of the various codes and much valuable discussion, covering a period of two days, the whole matter was referred to the

Code committee of seven to prepare a final draft for submission to the next meeting of the conference, which then adjourned to meet June 25 and 26, or subject to call of the chair.

Your committee feel that there is every reason to believe that the long-sought-for and much-to-be-desired end is near at hand, and that the formation of the National Conference upon Standard Electrical Rules will result in the near future in the adoption, promulgation and enforcement of one single recognized standard for electrical construction and operation; a standard code meeting fully the requirements and wishes of the electrical, insurance and allied interests of the country. Believing that the interests of the National Electric Light Association will be fully conserved by the National Conference, in which the association will doubtless continue its representation by an official delegate, your committee present herewith their final report, and beg to be discharged.

P. S.—Accompanying the report will be presented the voluminous correspondence of your committee and various other papers, three copies of the official code for the conference, full minutes of the conference held March 18 and 19, 1896, covering 176 pages of typewritten matter and including Captain Brophy's paper, various committees' reports, etc., and thirty copies of the standard codes forming the basis of discussion at the conference.

In conclusion, your committee most strongly urge the association to continue its representation in the National Conference, by the appointment at this meeting of an official delegate and the appropriation of a sum of money not to exceed twenty-five dollars, for carrying out the incidental expenses of the conference; other bodies contributing a like sum for this purpose.

Respectfully submitted,

William J. Hammer, Chairman,
Harrison J. Smith,
Wm. Brophy,
Jas. I. Ayer,
E. A. Leslie.
Committee.

DISCUSSION

Mr. Hammer: One word, Mr. President, upon this report. I wish to state that a committee of seven of the National Electrical Conference have secured a certain number of copies of the pamphlet that was prepared by your committee, and that formed the basis of the discussion on March 18th and 19th. There is a great deal of valuable matter in it; it consists of the codes already referred to, which are the standards in this country and abroad. The committee has only a limited number of them, but if those gentlemen who desire to make criticisms and suggestions on the various codes now in use will kindly leave their names and addresses with Secretary Porter, the committee will, so far as possible, see that those gentlemen receive copies of the pamphlet.

Mr. Seely: Mr. President, I move you that the committee's report be received and spread upon the minutes, and a vote of thanks extended to them for their arduous labors, and that the committee now be discharged.

Motion was seconded and carried.

The President: I desire to say that the vote of thanks to this committee is highly deserved. I think that if the accomplishment of what they have had in hand is successful, we can establish a national code of wiring and installation rules that will avoid the necessity, with which we are all familiar, of throwing out material that has been approved to-day and condemned to-morrow; which will be a great thing for the interests, not only of the association and its members, but of everyone who is interested in the growth of electrical business and installation.

MR. CLAY: Now, Mr. President, I move you that the recommendation of the committee, to the effect that the National Association continue its representation in this national body, and the payment of annual dues of twenty-five dollars, be authorized.

THE PRESIDENT: Do I understand that the appointment of this representative is to be left to the chair?

MR. AYER: I should like to amend the resolution by nominating Captain Brophy as representative of this association. He has already represented the association upon that committee.

THE PRESIDENT: I will say that Mr. Ayer's amendment to the motion is directly in line with the intention of the chair, so far as the appointee goes. Captain Brophy has already been the representative of the association. He was appointed at the meeting of March 19th; he has done work since that time on the committee as the representative of the National Electric Light Association, and the association does not propose to accept his resignation or declination.

MR. ARMSTRONG: Mr. President, I am opposed to this motion. I think we should make a serious mistake as an association if we undertook to choose a representative to represent us in this body. I have no objection whatever to there being a committee on this subject from this body. I have no objection, if it be the understanding that the chairman of that committee should become a member of this other national association, and there voice, as best he may, what we feel and think as an association. But I have the most serious objection to the National Electric Light Association being represented by one or more men in any other association whatsoever, national or international. I think that if we venture there we shall be making a very serious mistake all around. As we stand now, we are absolutely independent, standing for a certain purpose; able ourselves, by our constitution and organization, to cover the whole field, and not at all bound by any other body whatever. Do you not see that if we are represented in this body we are absolutely bound by its action? We might just as well go into the Underwriters' Association, if we could, and be bound by anything that they should say or do. To a certain extent, we are absolutely bound by what they do, but we are not consenting in advance to what they do. I should be very sorry to see this rash resolution adopted in the shape proposed. I should be very happy, so far as I am concerned, to have Captain Brophy represent any interest that I have in this line; but, as a member of the National Electric Light Association, I should be very sorry to see the association bound by any other national association, no matter how eminent or how trustworthy its objects, or how beyond any possible question the standing of its members. Whatever we do, we must do absolutely independently. I do not see how, under our constitution, under what we have so strongly insisted upon in the past, we could, by any sort of reasoning, adopt the suggestion of the committee in this line. I can readily see how naturally this suggestion would grow up. I can readily see how much more effectively the work that this committee had in charge could be accomplished by just the plan that is here suggested; but I should be very sorry, as I said before, to see this association go into any such arrangement, because the legitimate and necessary outcome of it would be for us to be represented in every national organization that had anything whatever to do with the varied interests with which we are connected and associated, and our absolutely independent, and somewhat unique, character would soon be entirely lost. I trust, therefore, that this resolution will fail.

MR. AYER: Mr. President, I am inclined to think that Judge Armstrong does not fully comprehend the situation as it presents itself. The prime object of the National Electric Light Association is to advance the electric lighting and kindred interests of the country. We were compelled to originate rules to better instruct those who have had no experience, to prevent unfair restriction being imposed on the methods that were in vogue and to justify the work that we did. In fact, there were many reasons why we had to make rules, simply because there were none. Through a long period, we have been improving those rules, and have at various times endeavored to secure co-operation with the insurance interests. After many efforts, we have succeeded in bringing about what seems to all to be the very best arrangement. We want to protect the electric lighting interests. We want rules that will be the best, and I know of no way to get them except by co-operation.

Now, this conference, as it is termed—and I think it is rightly named—is made up of single representatives from different national organizations, who are interested more or less in the establishment of proper rules for wiring. They influence, more or less, the rules that are made to-day. We have found, in endeavoring to fix a set of rules for our own government, that we have been compelled to give way to those of the insurance organizations, and they have declared and have maintained an arbitrary standard, to which we have all been compelled to submit. We have often realized the gross injustice of many of them, and yet there was no recourse, no help. By means of this conference, we to-day bring the insurance organizations in as members of a representative body, a limited organization; that is, it is numerically limited. There are, perhaps, eight or nine organizations that will constitute the membership: the architects, who have as much right as others to say what the rules should be; mining engineers, mechanical engineers, etc.; all of whom are interested in having rules and who are affected by them, and who are better able to tell us, in their particular departments, what should be the best practice than we are to determine when they come in with their particular reasons for desiring a change or modification of the rules. All important interests being brought together, each gets the support of all the other members of the conference for just and reasonable demands, and we shall secure a good, stable code of rules. The insurance organizations only intend to have that; it is their intention to have only proper rules. We do not want improper ones any more than they, but it is necessary many times to demonstrate that they are proper or improper, and I know of no better way to have our case presented there than through the best representative we can select, as the architects will have their case, and the various institutions working on independent lines. As for losing our individuality, I think we are gaining a strong point. We are here to accomplish the one object—the advancing of the electrical interests—and I know of no better way to secure a broad step ahead than to insure the establishment of standard rules, and add another reason for the permanency of this organization. I certainly hope that the motion will prevail.

MR. HAMMER: Mr. President, I think it is very essential here to state one important point; a point that I do not think Judge Armstrong realizes, and probably a good many others do not. It is not the intention of our committee that the delegate who shall be appointed to represent this body, or the delegate from any other organization who would attend that conference, shall in any way commit the association that he represents. He goes there representing his association, because of his knowledge of, and experience in, the matters that are to be discussed. He goes there to criticise and to suggest, and, in every way that he possibly can, to help boil this whole subject down into one single national code. When it is so boiled down, it is not to be arbitrarily adopted as the standard by any body or organization at once, and not to be rammed down anybody's throat. After a code is prepared, which will, to a certain extent, be a preliminary code, the delegates will go back to the National Electric Light Association, the American Institute of Electrical Engineers, the Mechanical Engineers, and other co-operating associations, and they will say: "This body, *i. e.*, the National Conference, which has so much interest in this question, has boiled this subject down into such shape that they believe it will meet with the general approval of the electrical, insurance and allied interests."

Now, the question is, whether the National Electric Light Association, with its able defenders, will approve of that report, and will deem it advisable to give it their indorsement and assist in its becoming the standard national code.

But let it be thoroughly understood here that we do not intend, as a committee—and the association does not intend, I am sure—that Captain Brophy, whom we recommend as the delegate from this association, shall go to the conference and in any way commit the National Electric Light Association.

I have the honor to be a member of the Council of the American Institute of Electrical Engineers. That is a very conservative body, and this very question that Judge Armstrong brought up to-day came before it and it felt that the Institute must not be committed by its delegate; but it was explained that we do not ask any of the associations to commit themselves at the conference to any final or binding action in regard to this matter; there was no difficulty.

We shall present a code that will be the best that these various able interests can prepare. We shall then hand it to the delegates, who will go to the various associations that they represent, and ask them to give their approval and support to what the conference recommends; whether it is adopted or not is left entirely with them; there is no forcing in any way. I certainly must indorse the remarks of Mr. Ayer, as to believing that it is the only possible way in which this much-to-be-desired end can be accomplished. Both electrical and insurance interests have tried to come together before upon this matter, but it has not been possible. They have now come together with other interests having much at stake, and the diversified and heretofore antagonistic interests were beautifully harmonized at the conference in New York City, March 18th and 19th of this year, and I think that every man who left that meeting felt confident that this long-desired end was about to be accomplished.

Now, do not let the National Electric Light Association, which has taken such a great interest in furthering this most important matter from its inception, try to block it just at the time of the consummation of this magnificent piece of work, so far-reaching in its importance.

MR. CLAY: Mr. President, I was induced to make the motion to adopt the recommendation of the committee by reason of the very convincing facts set forth in their report, which have been more than corroborated and substantiated by the remarks made by both Mr. Ayer and Mr. Hammer. Now, independently of their views on the subject, from a common sense standpoint, it occurs to me that there is but one action open for this association, and that is to have a representation in this national body. Under existing circumstances, every locality is at the mercy of the arbitrary action of the Board of Fire Underwriters with regard to the wiring of buildings in which electric light companies may be giving service; and, to correct very many abuses that grow up under that system, and to do away with very many disadvantages under which the electric light companies are laboring, it occurs to me that it would be the course of prudence, and undoubtedly the policy of wisdom, for us to seek to have, in such a body as it is proposed to create, a representative who would at least endeavor to see that the interests of the various electric lighting associations were taken care of.

Mr. Seely: Mr. President, I have some very dear friends on the committee that has just been discharged. I believe that committee is more ancient than the association. It has been in existence a long time. They have all worked hard, night and day, to accomplish the results that they have presented to this association to-day; but I am frank to say that I do not believe that any committee, appointed from any body whatever, will have any effect at all with the insurance people. This association has spent some three or four hundred dollars in printing, getting out statements, writing letters, collecting data, and getting up a set of specifications for wiring that have been extensively copied by the various municipalities in the United States. The large cities have all appointed electrical engineers, to some extent, and it is impossible to have a uniform system of wiring. We heard a paper read a few minutes ago on the subject of interior conduits. That paper condemns some systems and approves of others. Likewise, you will find that the architects in the large cities have their own ideas, and will insist upon their being carried out. If I should adopt a system and wire a building with it, spend five or ten thousand dollars in putting in a system approved by this association, probably an inspector of the insurance companies would come along and condemn it; I really do not believe that this or any other association can formulate wiring plans that will be universally adopted by the insurance companies.

Mr. Armstrong: Mr. President, any lingering desire that I might have had for this thing has been effectually dispelled by Mr. Ayer's remarks, followed, as they were, by what Mr. Hammer said. I thought I understood it, but when Mr. Ayer confidently said that I evidently misunderstood it, and Mr. Hammer said that I misunderstood one thing—as I did, so far as his remarks are concerned—I began to question whether I have not been rather premature in my charge that this body did not have any force or effect, only such as depended upon its own individuality. I presumed that it was so organized that its fiat would be practically the rule, and it could not be effectually dispensed with because it was associated with the Underwriters. I thought I gained that from the very full and very fair report of the committee. Is that true? Is it not associated with the Underwriters?

MR. HAMMER: The Underwriters is associated with it; yes, sir.

MR. ARMSTRONG: It would seem, therefore, to be somewhat superior to the Underwriters. Now, if that be true——

MR. AYER: That is exactly the case.

MR. ARMSTRONG: I thought that it was understood that this body so organized would themselves formulate rules that must be followed by everyone. Now, if that be true—and Mr. Hammer says not——

MR. HAMMER: That would undoubtedly be the ultimate outcome of the thing.

MR. ARMSTRONG: That is because the rules themselves will be so reasonable, and will so appeal to good judgment, that they would be foolish not to follow them. Is that the reason?

MR. HAMMER: Correct.

MR. ARMSTRONG: I have discovered professionally, if you will pardon this personal reference, that courts and juries are frequently so constituted that when the plainest, clearest and most convincing facts, both in law and in fact, are presented to them, they will go and do just the opposite thing. (Laughter.) I have had instances where, in my judgment, but one view could be taken of a thing, and the court and jury have taken directly the opposite view. If you are in the' last court, there is but one remedy, as they sometimes tell you, and that is to get out of their presence and then swear.

Now, one of the things that I do not know anything about, is what is safe or what is not safe wiring, and I do not mean to undertake to discuss that question at all. I am at one with you as to the desirability of having a code against which no one dare go, or can go with impunity, whether he be underwriter or what not; I am entirely in harmony with that. But we are peculiarly situated. We are jealous of our constitution as an association. This is composed primarily, not of individuals—although it may happen that individuals that are foolish enough or wise enough to have electric light plants of their own can be members of this association, but it is not because they are individuals, but because they have the power plant and central station—this association is practically composed of companies. I suggested a method by which, possibly, all the good could be accomplished that you could get from it,—by having a committee appointed, whose chairman should be, as far as possible, without any voice; and, as Mr. Hammer says, it is not desired that he shall bind the association, but the concentrated wisdom of this association, contained in its representative, shall be in that volunteer body that does not bind anything. Now, if that be true, let it be done in some indirect way; certainly not in this direct way, unless we want to lose the distinctive character that we have maintained up to the present time.

We come together for one purpose. We meet on one plane. Now, do not let us make a mistake, because this will simply be a precedent for something else that you will be sorry for in the time to come, or I much mistake. I want you to understand that I thoroughly appreciate the great work done according to the report of this committee; but I recollect that only a few years ago we adopted a most formidable set of rules—I think there were ninety-nine or one hundred—and we said: "These rules are so fair and so reasonable, they have so many safeguards, that any board of underwriters that will not accept them, or any insurance inspector that will not say they are the best that could be designed, does not know his business, and ought to get out of it."

MR. AYER: But you couldn't put him out.

MR. ARMSTRONG: And you can't put him out now, as I understand it. If you can show me any way in which this association can adopt rules that will enable you to say that unless an insurance company will allow your work or your plant to pass muster, when done in accordance with those rules, you will not insure with it, and thus bring the insurance companies to terms, why, I am willing to approve it. I am willing to vote for the National Electric Light Association's doing something when it can enforce what it undertakes to do. You can't do it here. Mr. Hammer's suggestion is that, instead of really having a voice in this, the representatives will merely carry back to the constituent bodies that sent them, a report of what the conference has done, and that is all it amounts to.

Now, gentlemen, I fear greatly that if we adopt any such thing as this, we shall not only be losing sight of what we were organized for, but shall be preparing a club that will come back to plague us very often, and we shall get many blows from it when least expected. I am entirely in harmony with all that these gentlemen want; but do not, for heaven's sake, let us do it in this way, unless we want to make trouble for ourselves in the future.

THE PRESIDENT: Gentlemen, Mr. Hammer's explanation is not in line with my original comprehension of the formation of this conference. I had the definite idea and impression that any representative appointed by the National Electric Light Association, or by any other of the associations to be represented in that conference, was fully empowered to speak for the association that he represented, and that unless we did put it upon that basis, the conference would be of no use. What we are looking for is an absolute, fixed standard of rules, which will be agreed to, not only by ourselves and the other associations interested in such questions, but by the insurance people as well; and unless we can have the associations that are represented bound through their representatives, we cannot bind the insurance people. What we want to do is to bind the insurance people to agree to a certain standard of rules, and not to allow any changes. If we can once get the insurance people on that footing, that is all we want. We are all interested, individually and as an association, in first-class wiring. There is no question about that. It is to our personal interest. We know that if we appoint a man that is familiar with the subject, we are perfectly safe in leaving questions of that kind to his judgment for decision, and we also know that he will use his influence to make those rules, as far as possible, in the interests of our particular side of the business. Judge Armstrong said he did not understand that our representative was to have this power. It was certainly my impression; and I think that unless he has that power, and unless all the representatives have the power to bind their various associations to the rules adopted, the whole purpose of the thing will fail.

CAPTAIN BROPHY: Mr. President, Judge Armstrong referred to the rules adopted by this association. They are good rules. I know something about them; I spent many weary hours with other gentlemen formulating them. They were so good that the Board of Underwriters adopted them as their own, without giving credit to this association. Had they stopped there—let them alone, and not mutilated them as they have done—all would have been well.

At the time of the adoption of those rules, it was understood between the representatives of this association and the insurance interests, that no rules should be formulated thereafter without the consent of both parties. It was not the fault of your representatives that the bargain was not carried out. Certain gentlemen, who represent the insurance interests in the capacity of inspectors, finding, perhaps, that their importance in that organization was not so great as it would be in a little one of their own, proceeded to form that little one, and are now making rules, when it suits their sweet wills to do so, that cost the members of this association thousands of dollars every year. Here is where the rub comes. This is what it is costing you gentlemen to gratify the whims and caprices of men that know very little of the financial end of the electric lighting business. It is an easy matter for them to condemn what they appoved a month ago, six months ago, five years ago, caring little what it costs those engaged in the business. For the last two or three years we have been at the mercy of this body; not the Underwriters themselves, for they know little about it; they have left the matter to these gentlemen, and you have suffered in consequence. Is it better to let this thing go on in this way, and allow the inspectors of the Board of Underwriters to tell you what you shall and what you shall not do? to order you to remove without a moment's warning, devices that have been approved by them in the past, regardless of what it costs you? Or will you be represented in a body where you have equal voice with other bodies and with the Board of Underwriters? I believe that the men to make rules are the practical men in the electric lighting business. I believe that the electrical engineer is the man to formulate the rules now, as he did originally, for the underwriters. You, gentlemen, are somewhat to blame for being at the mercy of the underwriters' inspectors. They hold their authority over your heads, and say that unless you heed their mandates, the insurance policy of your customer will be canceled. I have never known it to be done, and I have been in their employ a good many years in the past. (Applause.) The local underwriting agent—and here is one that has been in the business, and I think he will confirm what I say—is very loath to give up a good customer, and he will not cancel the policy of such a customer, thereby losing his revenue, at the dictation of any electric light insurance inspector. If you will not be quite so much afraid of this threat of raising rates because there is a cut-out that has no cover on it, or for some other trivial reason, or because in a perfectly dry place where for six, eight, ten or twelve years you have had underwriters' wire under wooden cleats, which has never caused a dollar's worth of loss to anybody, and never will; because you will not rewire buildings at your own expense or at the expense of the customer, lest his policy should be canceled or his insurance rates raised—when you have rid yourselves of this groundless fear, then you can act as Judge Armstrong indicates: You can dictate to the underwriters, instead of the underwriters' inspectors dictating to you as they do to-day. (Applause.)

MR. HAMMER: As the president and Judge Armstrong have referred to my interpretation of the powers of the delegate, I should like to make a statement. If this result is achieved, it will be achieved by the use of a great deal of tact, and by conservative methods. I think that when you gentlemen heard that list of organizations invited to attend your conference, you must have been impressed with the idea that it was not altogether an easy thing to get those important and conservative interests to even recognize such a movement and come to such a conference. It was not easily done. It was done because the statement was made to those various parties that this subject was going to be handled above board and in a broad-gauge way, and that the matter was not to be rammed down anyone's throat. It is the intention that this conference shall ultimately secure the general adoption of this code and its promulgation throughout the country, and secure certain legislation behind it. which, as Captain Brophy truly says, is not to-day behind the insurance interests. Now, you must all realize that in a thing of such importance, and dealing as we are with diversified interests and corporations representing so much, we cannot take high-handed methods, cannot be too radical; but we can, by being conservative and careful, and moving a little slowly, secure a certain code which will meet with the approval of the various delegates that are there; and when a delegate goes back to the National Electric Light Association, or to whatever body sent him, he will say: "This code has been approved at this conference by the representatives of all these interests throughout the United States. I bring this to you now, as your delegate, indorsing it and asking your approval, in order that when it is also approved by all the other organizations, the National Conference will send it out and it will then become the standard code of the United States." Now, gentlemen, it seems to me that that is the way this thing should be done. The committee that has had charge of this matter has considered it very carefully for a long time, and, as Mr. Seely has said, has worked night and day upon it, and they have felt that their action was such as discretion and wisdom would dictate.

MR. LESLIE: Mr. President, as the manager of a central station in New York City, I think I might say a few words pertinent to this discussion. The securing of a standard code that shall replace all the various codes now in effect in different parts of the United States is, I think, very important; important not only to the generators of electric current, but to the consumers as well, and, consequently, to the development of electric lighting generally. Now, in the city of New York we have a very unique state of affairs; one which, in some respects, is peculiar to this city alone. The matter of wiring is something that the average consumer does not understand or appreciate, and if the least doubt is cast upon its safety, it is sufficient to cause him alarm. In the first place, we have here the Board of Fire Underwriters as authority; in the second place, we have a legally constituted board or bureau of fire inspection, which is a part of the fire department of the city of New York, and which was brought into being by legislative action; in the third place, we have also a bureau of electrical inspection, backed up by a dozen or more of the influential insurance companies of this city; so that when we now want to turn current on a customer's installation, the actual process is to make application to the Board of Fire Underwriters and secure a permit; then, a similar application to the Bureau of the Fire Department, the legalized bureau of the city. Both employ inspectors, and it sometimes happens that the Board of Fire Underwriters will issue us a certificate, and we congratulate ourselves upon the fact, and very soon thereafter we receive a notice from the Fire Department that, in certain respects, our wiring is not up to the rules and regulations of their bureau, and hence they cannot issue a certificate. While, in the one case, if we fly in the face of the Board of Fire Underwriters, as Captain Brophy says, the customer is threatened with the withdrawal of his insurance policy; in the other, we are threatened with the penalties prescribed by law. In the third case, it sometimes happens that when both the Board of Fire Underwriters and the Bureau of the Fire Department have issued certificates, this other bureau takes exceptions, and then we have to do something for them. So you will see what a difficult matter it is for us to develop electric lighting in the city of New York, and how necessary it is that, however it may be brought about, a code of wiring that shall be adopted by all the organizations having influence or legal power, is a matter of paramount importance to us; and if we can get such a code, which will be recognized as the English Board of Trade rules are, for instance, the matter will be simplified very much; and it will then only remain for us to do our full duty under that code, which, I regret to say (and I am not now excepting my own company), the members of this association have not always been particular to do.

MR. ARMSTRONG: As nearly as I can understand, Mr. President, most of the remarks have been addressed to the desirability of having a fixed standard set of rules. You do not seem to understand that the method and the nature of our association, form the only objections that I have had. Now, I suggest a method, of which I do not altogether approve, I confess, but, in my humble judgment, it is so infinitely better than the other that I will submit this as a substitute for the motion now pending.

MR. WILMERDING: You make this as an amendment to the amendment?

MR. ARMSTRONG: No; it is a substitute; because, if this be adopted, it takes the place of the whole subject matter.

MR. SEELY: Judge Armstrong, would you accept a suggestion that the committee be members of this association?

MR. ARMSTRONG: Well, I suppose it would be impossible to appoint from here anyone not a member of the association. I do not know; I don't know what construction of the constitution will be made here to-day; I am getting a little fearful.

THE PRESIDENT: I should like the object of this change made a little clearer. In effect, this is the same as it appears to most of us. What is to be gained by the distinction—appointing a committee, instead of having a single man act?

Mr. Armstrong: The motion made was that this association appoint a representative to engage in this national conference, who, by that very appointment, then becomes, so far as any action taken there, this association absolutely——

Mr. Hammer: Not at all.

Mr. Armstrong: I am only speaking of the matter as it stands before the body; I don't know what you have got in your mind. If you adopt this, we appoint a committee that is absolutely powerless to do anything except what its constituents authorize and empower it to do. It cannot do a thing except to report to this body. Mr. Hammer says that was all that was desired; that the representative who went from here would go and bring back such a report as, by its wisdom, would so commend itself to this body, that this body would adopt it. Now, I think we have no right to send out a representative from our body; but if we appoint a committee, it can go to any point under the sun, or its representative can go, and bring back a report here. My purpose is not to stop what you want to do, but to accomplish it in a way that I think is altogether proper. I am perfectly willing, if you desire, to amend this resolution——

Mr. Ayer: I want to second your substitute.

Mr. Armstrong: Thank you.

Mr. Ayer: It is exactly what we want.

Mr. Armstrong: I was asked if I would make it. I will agree to this: *Resolved*, That a committee of five be appointed on standard electrical rules, which committee may designate some one—instead of some member, some one—to confer with the representatives of other bodies on the same subject, with power to expend not to exceed twenty-five dollars annually.

Mr. Ayer: I second the substitute.

Mr. Clay: I should like to ask Judge Armstrong to point out to this meeting any provision in the constitution of this association that precludes the adoption of the original motion; and I ask it for this reason: The principle recognized in republican forms of government, particularly such as we live under, is that the power is resident in the people, and it is a mistake to delegate the power of the people to the discretion of anybody else. Now, we propose, under the substitute of Judge Armstrong, to rob ourselves as a constituted body of the power to delegate and to name our own representatives in a conference, and the proposition is to relegate that power to a committee of five who shall discharge that duty for us; and I cannot see that any better end is to be accomplished by the adoption of the substitute than by the original resolution. I think that if we are to have a representative there at all, we should name him ourselves.

Mr. Armstrong: It would seem as though this were a waste of important time, unless you wish to change the character of the association. Now, Mr. Clay and I are absolutely at one. His definition, however, of a republic fits a democracy, but not a republic. We only have the power that our constitution gives us. What power has the United States other than that given it by its constitution? None at all; all the rest remains in the people. The difference between the States and the United States is so great that I suppose it would be a waste of time and an insult to your intelligence to undertake to explain it. We have as a convention only such powers as are given us absolutely by our constitution; no more than that; and unless Mr. Clay, or Mr. President, or some one, can point me to some power resident in our constitution conferred upon us, there is no power resident in this association to send a representative to any other body with power to speak for and bind the association. That is my objection. It is not that they shall not go to the uttermost parts of the earth and bring in all the possible wisdom they can; they ought to do it, and that is why I am willing to send out a committee to gather and bring in everything. But it is that I am not willing to send out an ambassador or a minister plenipotentiary, to go out and say, "I am a National Electric Light Association within these lines." I have the greatest confidence in the gentleman suggested, because he has stood firmly and solidly by the electric light companies all the time, in and out of season; it is because I have confidence, and because he knows I have that confidence, that I dare to speak earnestly upon this somewhat delicate subject. It is not that I love the Captain less, but that I love the National Electric Light Association more. (Applause.)

The president then put the question as follows:

Resolved, That a committee of five be appointed by the president on standard electrical rules, which committee may designate some one of its members to confer with representatives of other bodies on the same subject, with power to 'expend not exceeding twenty-five dollars annually.

A division being called for, a standing vote was taken, and President Wilmerding announced that the question was carried, and that the original motion and amendment would fall.

STANDARD OF CANDLE POWER FOR INCANDESCENT LAMPS

MR. AYER: Mr. President, the desire to establish some sort of standard for our incandescent lamps is very strong among some of the members. To-day, we have nothing as a standard. It seems to me necessary that some steps should be taken toward establishing a standard that shall be as accurate as may be. As to the details for the final accomplishment of this object, it seems to me that they should be taken up by some committee that would devote the necessary time and attention to the matter; but I would recommend, and I offer it as a resolution, that a committee be appointed from this body to confer with representatives of the American Institute of Electrical Engineers, with a view to adopting some standard for a sixteen-candle power lamp, or for our incandescent lamps, so that all manufacturing companies may have a standard to work from and all operating companies a standard to go to.

The motion was seconded.

MR. STETSON: I should like to ask whether or not that is intended in any way to perform the same functions for the electric lighting companies as the adoption of the insurance rules in reference to insurance. It is not a new idea, but it was recently stated to me that the time would come, if it had not already come, when central stations whose business it was to furnish light, or, in other words, to sell current for the production of light, would sell it as a product on whatever standard they saw fit to adopt; not on a sixteen-candle power lamp standard, or twenty or twenty-five, but that that part of the business belonged outside of the central station; in other words, that incandescent lamps would be sold on the market the same as gas chimneys are sold, or candles, or oil, by measure; and that the central station would sell its current at so much per thousand watts, or anything else that might be adopted. It would relieve the central stations of all question as to whether they were giving one candle power or another. Now, that struck me, if it were practicable, if it could be worked out, as being the best way to relieve the central stations of a great deal of trouble. There is no rule that this association can adopt, or that any manufacturing company can adopt, that a lamp shall be of so many volts, or so many amperes, or watts, or whatever you choose to call them,—that will satisfy the customer, who is the complaining element. You can never get them to understand it. But if they are put in a position to buy these lamps, good, bad or indifferent, as they may be, and are obliged to pay the company furnishing the light for the quantity of current that they use,—if you will adopt that, you will relieve yourselves of all that annoyance and throw the responsibility upon the user.

MR. RHOTEHAMEL: Mr. President, the whole difficulty at present is that we have no definite standard. It is true that the standard candle is derived from the burning of sperm candles and the weight of the candle used in determining the standard candle; but different persons making the observation from the candles get different results, and the consequence is that we have a varying candle power from different manufacturers of incandescent lamps, ranging all the way from six to eight-candle power difference in a sixteen-candle power lamp. The object of this resolution, as I understand it, is to establish a standard candle power, and the user can then determine whether he wants a sixteen-candle power lamp, according to this standard, or a twenty, or a thirty-two, or an eight-candle power, or whatever it might be.

It only places the matter in this way: that when you buy an incandescent lamp of fifty watts, sixteen-candle power, that it means something, and that each manufacturer would then be required to furnish an incandescent lamp that is the same as the other manufacturers are required to furnish, and you get something definite. My idea is that this can be accomplished by placing it in the hands of the American Institute of Electrical Engineers, letting them make a standard candle and preserve it, the same as the inch is preserved, so that we know where our standard is derived from.

MR. WILKINSON: I should like to ask whether this standard lamp is to be a lamp consuming a certain amount of current and producing a certain amount of illumination?

MR. AYER: It is to determine what a candle power should be, not its efficiency.

MR. WILKINSON: Then, we are to sell this lamp on a certain candle power, irrespective of the amount of current it is consuming?

MR. AYER: Oh, no.

MR. WILKINSON: Can't you go to any manufacturer to day, and get any candle power you want?

MR. AYER: Yes; but the trouble is with the standard. It is believed that something much better than the standard sperm candle can be established as a standard for comparison. The object is to get something definite to start with, so that when you buy a sixteen-candle power lamp, you will get a sixteen-candle power lamp according to the standard it is proposed to adopt. It will be a national, or American, standard.

MR. WILKINSON: Is that candle power determined by the eye?

MR. AYER: No; by measurement.

Mr. Wilkinson: I fail to see how that is possible. You take a barrel of lamps, and I defy any man to go over them and call them all the same candle power.

Mr. Rhotehamel: There are some lamps advertised as forty-watt, sixteen-candle power lamps, but when you make measurements they are not that as a matter of fact. Now, if we get something that requires it to be a forty-watt, sixteen-candle power lamp according to the American standard, it means something; it is something definite and certain. You want to better your service, and this will better your service, because then when you order a sixteen-candle power lamp from any manufacturer, you will get a sixteen-candle power lamp according to the American standard. That is what we want to accomplish. Lamp manufacturers and users will then have one and the same standard from which to derive the candle power of incandescent lamps.

Mr. Wilkinson: Does not science produce a standard? Doesn't candle power mean something?

Mr. Ayer: Yes; but it is not definite.

Mr. Wilkinson: The only thing you can do is this: you can say a lamp consuming a certain current is a certain standard, which means nothing at all. You take a lamp to-day that is consuming forty-four watts, and another sixty, and you will get more illumination from your forty-four than from your sixty.

Mr. Ayer: Not necessarily.

Mr. Wilkinson: Not necessarily, but it may be so.

Mr. Wagner: Mr. President, it seems to me that there is a perfectly definite standard of candle power. The English standard is practically adopted all over the country; the only difference is a question of measurement of the use of that standard. It seems to me impossible to obtain a closer or more definite standard than the one in use, although it seems desirable to have that standard used in a more definite way; and the way to obtain what is desired would be the establishment of something like a bureau of standards, which should standardize incandescent lamps and dispense them to the manufacturer and user; that those lamps should be used for comparison and be considered standard lamps. The present standard is definite if it is used properly.

THE PRESIDENT: Did Mr. Ayer's motion mention the number of the committee?

MR. AYER: No.

The president put the motion as follows:

Resolved, That a committee be appointed by the president, to confer with a similar committee of the American Institute of Electrical Engineers, to effect a standard of candle power for incandescent lamps.

Carried.

The convention then went into executive session.

SPECIAL EVENING SESSION.

LECTURE BY D. M'FARLAN MOORE ON THE LIGHT OF THE FUTURE.

During half of man's existence the earth is robed in darkness. But his conquest over darkness alone establishes his supremacy over all nature. Ancient history indicates that man never permitted night to rule with absolute power. Her domain has always been invaded,—the torch, oil, gas, and finally electricity, being the implements used against her sway. None of these, however, can compare in the slightest degree with day, which completely vanquishes night every twenty-four hours. Day, the conqueror, represents the ideal light, and man, in his attacks upon night, cannot do better than attempt to imitate her.

But wherein does man's artificial light of the present differ from daylight?

First, he still follows in the footsteps his primitive ancestors were compelled to take; viz., he produces lights, not light; and, secondly, the color of his lights is far from duplicating the soft and mellow light of day. Although the Greeks and Romans were far advanced in many branches of science, the crude, smoking oil lamp was the limit of their attainments in artificial illumination; but a number of centuries have passed since then and I venture to say that the time is already here when this hall can be so lighted that the difference between the light of night and the light of day would be barely perceptible. In fact, the "unbroken day" can now be a reality, units of light in the illumination of areas will gradually disappear and night will be but a slight inconvenience. Again, from a hygienic standpoint, all present forms of illumination are found wanting in a greater or less degree. The brilliant glare of units of light is decidedly harmful to the eyes, and if the heat thrown off could be entirely avoided, personal comfort would be increased. The new light should possess all the advantages of methods now in use, and, added to them, many more.

Most of us, being brought into contact with nothing to the contrary, are at first puzzled in an attempt to dissociate light from heat, and are also apt to associate darkness with cold. But it is now generally accepted that light and heat are merely the manifestations of energy under certain conditions, and that all forms of energy are complex; that is, contain all the other forms, but one of which predominates. The great modern agent of the world is electricity. It is the handmaid of the housekeeper, the servant of the business man, the "messenger of the nations" and the hope of scientists. It is needless for me to tell the body I am addressing that electricity affords the best commercial means of illumination at present, and will continue to do so in the future; only different methods will be pursued—the entire abandonment of those now in use.

Humanity demands, besides food, light, heat and power; but if it has electricity, it can have them all; that is, roughly speaking, heat can be produced without light accompanying it, power without heat; but heretofore it has been impossible to produce a considerable volume of light with a minimum of heat; yet this is what modern progress demands. The only method known at present for obtaining this ultimatum is by the utilization of light emanating from a rarefied gas within a transparent receiver, the light resulting from the agitation of the gas by electricity. Now, when an improved light of this nature, that is, cold light from glass tubes (not hot light from glass bulbs), has been generally adopted, we shall be in possession of a form of illumination that has many more good qualities than the incandescent lamps and none of the bad ones.

It will revolutionize architectural designs for beautifying interiors. Abundant light is becoming more of a necessity and less of a luxury every day, and the tendency, in general, is toward the ideal method of lighting; that is, radiation from a source of considerable area, in distinction from intense lighting of fixed centres of diffusion. Comparatively speaking, recent improvements in artificial lighting have been more rapid than most of us realize. Electrical manifestations that attracted public attention but a short time ago are now considered unworthy of notice. We all remember when the "great electric arc light" was one of the leading attractions of the country circus, or when crowds would gather to see an incandescent lamp nestling among silks or other inflammable materials in a show window, and the awe and respect which country folks displayed when told that it was a lamp that they could not blow out and did not need a match to light it. The audience here to-night indicates, in a measure, an interest of the same nature, and what is here shown soon bids fair to be commonplace. Light is something that is intensely attractive, not only to the animal, but also to the vegetable kingdom. What do you remember most vividly of the World's Fair? The machinery? No; the lights that glittered in every direction after the sun had gone down and Erebus attempted to rule the "White City."

The greatest triumphs of electrical illumination and decoration are most certainly those that still await it.

I will now call your attention to a method which tends toward the production of an illumination more nearly satisfying the specifications suggested.

The well known Geissler tube was invented over a century ago, and consists, usually, of a small piece of glass tubing with metal terminals sealed into its ends, and from which the air has been partially exhausted. When electricity in the proper form is applied to such a tube, a strangely attractive white light results. It is so attractive because it is at once noticed that it is a light entirely different from all other forms to which we are accustomed. It differs, not only in its even diffusion from its entire area, but also in that when it is touched it does not burn the hand.

There is no form of artificial light where heat is almost absent. It is a concomitant of light in all forms of illumination, but it is an unnecessary evil.

The light that you now see in this tube, although faint, is very efficient; that is, when you consider the extremely small amount of electric current that actually passes through it and note that seventy-five per cent of this small current is turned into light; and when you remember that the incandescent lamp, under similar conditions, transforms but two per cent of its current, you will wonder why lighting by luminescent gas has not been utilized long ago.

The main object of the body I have the honor to address, the National Electric Light Association, is to produce incandescent light through the agency of electricity. This yóu do, but actually your main object (light) is but a small by-product of what really consumes your coal piles; viz., heat.

Why, when you desire to transform one hundred tons of coal entirely into light, do you transform ninety-nine and seven-tenths tons of it into useless heat? Because means for so doing have not yet been discovered. But they undoubtedly will be, and we are marching rapidly toward that goal at the present moment. When this problem is finally and completely solved, the electric current will be produced directly; that is, without boiler and steam engine—and this current will then be attached to tubes containing the proper gas. But the tail-end only of the system that has just been prophetically outlined is already at our command; viz., the tubes; and even their efficiency, though great, needed improvement, and the faint light they had previously been made to give seemed to utterly debar them from so brilliant a future as to furnish the "Light of the Future;" therefore, there was first needed some method of actually getting light of commercial volume from the tubes.

But to accomplish this required that the second step be taken; that is, that a proper current for agitating the tube into a bright light be discovered. It is my privilege, among others, to call your attention to such a current, and it will thus be seen that I have directed my efforts toward the solution of the final steps of the great problem, rather than toward the fundamental step; that is, although a great loss in the process of manufacturing light is between the coal and the current (and with this Gordian knot the scientific world is still wrestling), the other great loss is between the current and light. But, irrespective of loss, "manufactured sunshine" coùld not be obtained except in very weak and small quantities. The importance of the problem that has been solved cannot be fully comprehended until it is stated that the ordinary commercial lighting currents can be used to produce this light with the addition of but small and inexpensive apparatus. The light of the future may then come into use long before the present wiring outfits of buildings and streets, representing millions of dollars of invested capital, are relegated to the scrap heap.

The main reasons, then, why tube lighting has not been commercialized, are: first, it has been impossible to get in this manner more light than a faint glow; and, secondly, in order to get even this faint glow, required massive, expensive, unreliable and uneconomical apparatus to produce the current necessary, which, after all, was impracticable to insulate or distribute. The apparatus most commonly used for producing current and light of this nature is the induction coil. It consists of two lengths or coils of wire, one outside of the other. The smaller (and usually the inside coil) has an electric current passing through it, which is stopped and started--that is, interrupted—about a thousand times a minute. Between the two ends of the outside coil the Geissler tube is attached. The current that is interrupted usually has a potential of from four to six volts; but the current in the outside coil, which results therefrom, has a potential of many thousands of volts. Why, it may be asked, is so low a voltage used in the inside coil (the primary)? Why not use a current similar to that in an incandescent lamp, say, 110 volts? Principally, because heretofore a current of more than a few volts' potential could not be disrupted suddenly, and upon this largely depends the resultant current and light. I will now try to make this point more clear.

Permit me to draw an analogy between a current of water and a current of electricity. When water flowing through pipes is interrupted *suddenly*, a sharp click is often heard. This is due to the strong back action of the water, sometimes causing the pipes to burst, indicating that the reflex action of the water produced a greater strain or pressure than the original head. Just so with the electric current; when it is interrupted suddenly, a current of much higher voltage results. It should be remembered that the water pipe would never burst were it not for the *suddenness* of the interruption of flow. In like manner, if the electric current is interrupted, and each interruption takes place in a minimum space of time, the maximum resultant voltage, or current electromotive force, will be obtained from a given coil of wire.

To secure the proper number of interruptions of the current for a given sized coil is not so difficult, and can be worked mathematically. The more perplexing problem has heretofore been to reduce to a minimum the length of time necessary for any single complete interruption. But, in order to discuss this problem, the words conductor and insulator must be used. These terms are, of course, merely relative; that is, anything in the world will conduct an electric current, but there are some substances that will do so more readily than others. The substances that offer the most resistance we call insulators; the least, conductors. But conductivity is not alone confined to material things, but, of course, includes within its scope aeriform bodies and gases. For example, steam is a better conductor than air or water, but a vacuum is the poorest conductor known. When an electric current is broken, that is, interrupted, in ordinary air, an arc exists for the instant after the metal electrodes have separated.

The main reason for this is that the conducting properties of the air are brought into play, and therefore there is not a short and clean break in the circuit. It objects to being interfered with, and its struggles for continuity are long drawn out. Here, indeed, is a case where an instant's delay is dangerous to the character of the reflex current.

How can this exceedingly detrimental delay be avoided? By breaking the current in rapid succession in a vacuum, where there is no air to help the current across, is my solution. One method of doing this is by means of a little device (about three inches long and half an inch in diameter), which I have named a vacuum vibrator. Combining such a vibrator, a small coil of wire and an evacuated glass tube, with a commercial current, a brighter light of this kind than has heretofore been known can be produced. One point to be noted is that the vacuum vibrator enables the sudden disruption of currents of comparatively high voltage as compared with those generally used in induction coils and produced from a few cells of battery. When the small tube containing the vibrator is placed with reference to the magnet as shown, and the current turned on, of course the circuit will be rapidly broken in the vibrator tube; that is, in a high vacuum. This repeated interruption of the circuit causes an increased counter electromotive force to be brought into existence in the magnet, which, if conveyed by two other wires (not in the main circuit) to another tube, but containing nothing but rarefied gas, it will give forth light that is strong, uniform from end to end, without striations and without flickerings. In the case of a straight tube, it is a glowing cylinder of light of a diameter equal to that of the tube.

But the kind and quantity of light depends largely on the degree of rarefication of the air within the large light-giving tube. For example, here is a piece of apparatus where the two vacúa are merged into one, and the vacuum in it is low; and, therefore, the light consists only of a delicate purple envelope around the wire. The tube now shown does not contain a vibrator, but a wire so bent as to spell the name of one of America's greatest electricians, Henry. It should be noticed that the wire connecting this tube to the vibrator is attached to the armature terminal of the vibrator, not to the contact point, because it would not then receive the discharge of the magnet and no light would result. However, the high potential pole must be negative, in order that the purple light appear. If the vacuum is raised, the light appears like a beautiful white smoke, filling the tube. If, now, the interior conductor be made to assume various forms, a large field is open for investigation. I have observed a great many beautiful phenomena with tubes and lamps constructed in this manner, but will light up only a few of those that are interesting from their novel forms, and also because they possess peculiar scientific features. The light is greatly improved by placing two terminals in the bulb, and connecting the larger one to the high potential of the vibrator and the other to the low potential terminal. Another new and most important principle in the construction of the internal conductor, is that it be so formed that the field of force of one portion of the conductor will overlap or intersect that of another portion. By properly using this principle, the intensity of the light may be increased many fold.

Good results can be obtained by bending the wire in the form of a cylindrical spiral, or by finely subdividing it and using, instead of a glass tube, an ordinary incandescent lamp bulb. The positive electrode can then be made in the form of an aluminum ring in the neck of the bulb and the negative electrode extend into the body of the bulb. It can be made in an endless variety of forms, including plane surfaces. The smaller or positive pole can be placed anywhere in the bulbs without affecting the light, and much light is obtained from lamps in which the negative terminal consists of a large number of fine subdivisions. This can be accomplished by constructing it out of many loops of fine wire or carbon filaments.

It is interesting to note that intense light in these lamps does not mean intense heat, because substances placed in the centre of a bright pencil of light are not affected at all.

The most prominent feature of the glow lamps is that the light is perfectly steady. If a tube with terminals sealed into the glass at the ends be used, marked striations immediately appear, with a consequent unpleasant flickering of the light. If we now substitute for such a tube another, which is its exact counterpart in form and size, except that it is entirely devoid of electrodes, we shall observe, after the wire terminals are each wrapped several times around its outside at its ends, that the light is perfectly steady. This feature is of great importance, but it is second to the fact that there is nothing within the tube save the residual gas, and therefore its life is almost unlimited. On close examination, both sight and sound tell us that the wires at the ends of the tube do not make good contact with the glass, and the slight sparking taking place is detrimental to the volume and steadiness of light. This is cured by painting the outside of the tube at its ends with a thick paint made by mixing an alcoholic solution with powdered aluminum and bringing the wire in contact with the paint. This tube has been treated in this manner, and the great increase in the volume of light is apparent. There is no necessity that the two coatings of metallic paint be of the same size; in fact, the one attached to the low potential terminal may be but one-half the size of the high potential coating. If a number of large insulated sheets of metal be connected to an electrode, the light is decreased thereby. Of course, the result is the same if it be grounded.

These coatings can be placed at different parts of the tube and connected in a variety of ways to a number of vibrators, but maximum intensity of light occurs when coatings of equal size are placed at the ends of a tube, and each connected to a high potential terminal of a vibrator, and the centre of the tube attached to the low potential pole. That the light is largely due to the difference of potential, and that polarity is of little importance, can be shown in cases of this kind. The terminals of the tube can either both be high potential plus or both be high potential minus; or one end high potential plus and the other end high potential minus, and the middle terminal can either be low potential plus or minus; but the tube is equally illuminated throughout its entire length in all cases.

As stated before, to get the best light from a lamp, the terminal of greatest area must always be negative, irrespective of its potential; with tubes the case is different, viz.: to get the best light the largest electrode should be the one of high potential, irrespective of polarity. This fact can be illustrated in the case of tubes with or without electrodes. An electrodeless tube is shown as it appeared under the discharge of a weak current. The apices of the cones of light from each end meet at point X, which remains stationary whether the high potential terminal be positive or negative. With a tube of the same size, but provided with electrodes, the phenomena are the same, except that when the high potential is negative, dark spaces appear for a distance of about one-fourth of an inch in front of both the aluminum disks forming the electrodes; but when the high potential terminal is positive, the dark space appears only in front of the low potential and negative pole.

If three coatings made of tinfoil be insulated with oiled paper and placed one on top of the other at one end of a tube, and each coating connected to a high potential terminal of a vibrator, the light will be slightly increased over that obtained from the same tube by a single vibrator; but not so much as that obtained by three tubes, each connected to a vibrator.

The importance of having close-fitting metallic caps (best constructed by using a paint of metal powder) covering the glass at the ends of the tubes, has already been touched upon. But if the electrical connection between the conductor and the glass is of such importance, and since it is the electrical action of the current on the inside of the glass that agitates the molecules so that they give forth light, the logical interrogation is: What part do the thickness and the composition of the glass play in the production of
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to thickness: Five tubes were made up,

each one and seven-sixteenths inches diameter and one foot, three and one-half inches long and supplied with exterior painted electrodes two and one-fourth inches and one and one-fourth inches long. Tube one was made throughout of heavy glass averaging one-eighth inch in thickness. Tube two was made of thin glass throughout, less than one-thirty-second of an inch in thickness. Tube three was made of glass of the same thickness as A, except that the glass beneath the caps was as thin as possible—probably less than one-sixty-fourth of an inch. Tube four, same as A, but provided with two aluminum disks acting as interior electrodes, besides having the exterior caps. Tube five, same as A, but at its centre was blown a bulb over three inches in diameter, causing its walls to be very thin.

Upon trial, no difference was discernible in the volume of light emitted by one and two, and it was greater than that of three.

When the interior electrodes of four were used alone, the light was very poor, but subject to irregular brilliant rushes of light, with striations. When the exterior caps alone were used, the light was also poor, but steady. Where adjacent caps and disks are connected together, striæ seem to find difficulty in formation, but the light is no better. All of these tubes were given the same degree of exhaustion, and all were made of American glass. Two tubes received the same vacuum, and were each three feet long and one and one-fourth inches in diameter; one of American (lead) glass and the other of German (lime) glass were tried on the same current vibrator and magnet. The tube of American glass, though it had walls appreciably thicker than the other, gave considerably more light.

The light from a tube eighteen inches by one and three-fourths inches diameter, of ordinary American glass, but with its ends three inches long, made of glass containing a maximum quantity of lead, was considerably less than that from a tube of the same size but made entirely out of ordinary American glass.

All these experiments go to show that the light is due to electrostatic phenomena.

Tube B was then used to determine the effect of a magnet on the light in an electrodeless tube. The result is best shown by the illustration. The discharge is repelled from the inside surface of the tube towards its centre, and when viewed from above, that is, in line with the axis of the magnet, it is separated into two branches of about the shape outlined. Reversing the polarity of the current on the tube or the high and low potential terminals, produces no change in the outline; but reversing the magnetism of the magnet causes the outline to be reversed; that is, one and two go to opposite sides of the tube from those represented. The space X was filled with slightly fainter luminosity.

A given rate of vibration may produce maximum light in a lamp made by using a sixteen-candle power incandescent bulb, but if an electrodeless tube be substituted for the lamp, it will give its maximum light only after the rate of vibration has been considerably increased. Too high a rate, however (obtained by varying the distance of the vibrator from the magnet core), will diminish the light.

If one end only of a tube be connected to the high potential terminal of the vibrator, the light will e greatest in the end of the tube nearest the cap nnected; and if the other end be grounded or grasped in the hand, the light will many times increase. If one end only of a tube be connected to a low potential terminal of a vibrator, it is seldom that any light whatever results.

When two high potential bands are placed at the same end of the tube, but separated from each other, and one or two bands at the other end, an intense light will appear in the small space between the two high potential bands, and the main body of the tube will be almost dark.

An ordinary electrodeless tube, connected in the regular manner, will light up the instant the circuit is closed, provided the temperature of the room is normal; but if it be cold, five or ten seconds will elapse before light appears. If the tube has been used before, the moment any light at all appears it will be at its maximum; but if it be a new tube, that has just been taken from the mercury lamp, the light will at first appear cloudy, and will require a minute or two to clear up into an intense white.

Not only the temperature of the interior of the tube and the glass is affected by the current, but also that of the exterior electrode; and when sufficiently high, and, therefore, more conducting, the discharge evident in the form of light results. Another way of illustrating how a description discharge is aided by raising the temperature of glass, is shown by attaching a high potential lead to the shell of an incandescent lamp, and a low potential lead to a small disk of. tinfoil concentric with the top of the lamp. When the circuit is first closed, for a moment there is no demonstration whatever; then a single streak of miniature lightning passes from the base of the lamp, a second later quite a number of discharges occur almost together, and in a few moments the lamp appears to be encased in a cage of fiery streaks, due to the increased conductivity of the glass on account of its rise in temperature. It will be noticed that, although these discharges occur spasmodically, nevertheless, each separate discharge appears in the form of a comparatively short but continuous thread of light. I have, however, noted a discharge from a magnet, the whole length of which was broken up into short dashes. The circumstances under which this was noticed were as follows. The circuits were made up as shown: The wire at A sagged down until it got too close to C B. A discharge occurred, which melted the wire between the points C and B. The room was then in darkness and there appeared between B and C a discharge of the kind and length shown.

If a tube be bent in the form of a circle, care being taken that its ends do not touch, the light is but slightly affected. Also, if an endless tube be constructed with its terminals located at the ends of a diameter, the light is still the same. A circle of continuous light of this kind is artistic, and suggests artistic designs without number. The electric fountains of the future may indeed be electric fountains entire; that is, without water. Here is one in miniature. It is a practical demonstration that the glass receiver can be made in any form whatever that one's imagination may suggest.

The broad field opened up for the fashioning of tubes will result in the evolution of refined, delicate, artistic and classic designs in endless variety. Some of the unique and original designs that will be ought into play will make a veritable wonderland he future world's fair exhibition.

n electrodeless tube was constructed eighteen inches long over all, one inch in diameter at the ends, six inches at its middle was one-half inch in diameter, but two inches at the centre was one-fourth inch in diameter. The light was most intense in the centre where the diameter of the tube was smallest; less intense in the parts one-half inch in diameter, and least intense in the ends; but the total amount of light given was the same as though the tube had been one-inch in diameter its entire length without any contracted portions. Again, the maximum production of light from a tube is directly dependent upon a certain proportion existing between the length and the diameter of the tube. To prove this, here is a tube of the same diameter as those that give an excellent light, viz., one and seven-sixteenths inches, but only five and one-half inches over all in length, and provided with caps each one and one-half-inches long. The light produced is very poor indeed. There is a tube of fixed dimensions that will give a maximum light for every stated amount of energy.

The tube herewith described shows very clearly the effect of material substances when placed directly in the path of the light discharge. The tube is one and one-half inches in diameter and eighteen inches long, and provided with ample caps at both ends. Midway in its length is placed a mica disk with a hole about one-sixteenth of an inch in diameter at its centre, so that, of course, the degree of vacuum is the same throughout the tube. It filled with a uniform glow on both sides of the disk, and of equal intensity. But, as shown, the discharge passed through the hole in the mica. For one-fourth of an inch on each side of the hole extended a bright tuft of light, which was most brilliant on the side nearest the positive terminal, whether it was high or low tension. When the high potential terminal only was connected, the discharge took the shape outlined, and was not affected by changing the polarity of the current. When the current was made very weak in a similar tube without the disk, the apex of the cone of light was at A; but with the disk, it did not extend at all beyond it, irrespective of polarity.

The coating at the ends of a number of tubes was made so that it covered only the sides of the ends of the tubes; that is, not the ends proper. When such a tube is viewed in the ordinary manner, that is, from a line perpendicular to its length, the light appears very dense, and of a color closely resembling daylight. But when this tube is viewed in the line of its longitudinal axis, or, better still, if a piece of white cardboard be held about six inches from its end, there will appear upon it a circle of light equal to the diameter of the tube; but instead of an intensely white color, it will have a yellowish tinge, quite bright, but such as might be expected from an oil lamp.

It should not be inferred from this that a great depth of so-called phosphorescent light would change its color, because in this case the molecules of the rarefied air are viewed in the direction of their greatest free path, and also because tubes of varying diameters, if properly exhausted, give the same colored light.

Let me now call your attention to that class of phenomena known as induction effects, where light appears within bulbs, tubes and the like, when they are in no material contact with any source of current. Although one is perfectly familiar with the manifestation of electric force, it is always impressive. This tube consists only of a plain piece of glass, touching nothing save the hand that moves it back and forward. It contains no light, but the instant that switch on the table is closed it suddenly fills with a most beautiful light; its movement has not ceased.

Several feet above my head is a wire netting which is connected to the vibrator. As stated before, the frequency of the vibrator is very slow, yet this light by induction is due to vibrations that are rapid in the extreme, in connection with an intense electrostatic strain.

The effect that capacity has upon the light can be plainly shown with this tube. If it is supported by this wooden holder, it remains perfectly dark; but when the capacity of the body is added by touching it, immediately it glows. We can easily imagine that the pillar of fire by night, which guided the Israelites in the wilderness, had some of the characteristics of this light. A casual observer might suppose that as formerly we lighted by fire, we do so now with smoke.

Here is another tube, similar to the last with the exception that it contains several millions more gas molecules, that is, rarefied air, and therefore the light is of a ruddy hue.

Many gases have been experimented upon in tubes and lamps of this kind, in the hope of obtaining the gas that could be most easily agitated, causing a maximum white light with the most desirable spectrum. Traces of hydrogen will give the light a crimson color, and carbonic acid gas or chlorine, a greenish appearance. Traces of turpentine cause the tube to fill with a cloudy or milky white, but a few grains of ordinary table salt inserted in the tube improves the light wonderfully. It is apt to give the light a bluish tint, but this is entirely dispelled when the discharge is dense enough.

That the length of the mean free paths of the molecules has something to do with the light, is shown by these induction effects. If a vacuum tube be bent in the form of a ring, and held close to the wire screen connected to the vibrator, but with its plane parallel to it, the light within it is very faint. If, however, it be so placed that its plane is perpendicular to that of the screen, it lights up brilliantly and at a considerable distance. By these effects it can also be shown that, the more intense the field, the brighter the light; because if three screens, each connected to separate vibrators, be placed parallel to each other, the light in the tube will be brighter than if but one screen is used. A curious thing noted in this experiment was that the vibrators worked with great difficulty when so connected.

A screen of wire fly-netting six feet long and three feet wide gave far better inductive results than those obtained from a piece of sheet zinc about one foot square; besides, of course, the effects took place over a much larger area. Of course, when another screen was placed on the floor directly beneath the one on the ceiling, the light in the tube held in the hand was greatly increased. When both of these screens were placed on the ceiling, one about two feet below the other, but only the upper connected to the vibrator (the lower one connected to nothing), the resulting field beneath them both was not so intense as when the lower screen was removed. For example, a tube lit up at a distance of two feet when but one screen was used, but when a second screen, not connected to anything, was interposed between the connected screen and the tube, it would not light up at 'a greater distance than one foot. But if the lower screen is considerably larger than the upper, the field is cut off entirely; that is, no light will appear in the tube, even though it be brought into contact with the lower and larger screen.

The color of the light of an electrodeless tube is by no means dependent upon its degree of rarefaction, as the following experiment shows: The tube used was two feet long, one inch in diameter, with three-inch electrodes at its ends. When connected in the ordinary manner, it was filled with a uniform white light, the color of which was not affected either by changes in the rate of vibration or the resistance of the magnet of the primary circuit, but, of course, the intensity of the light was changed. Neither was the color changed when the low potential terminal was disconnected or grounded, or when high resistances were placed in the high potential lead to the tubes. But when the hand grasped one end of the tube, and the other was placed in contact with the high potential terminal of another tube connected in the regular manner and emitting a white light, the tube in the hand was filled with a delicate though brilliant light of a pinkish purple hue. Again, if a long tube, say, eight feet and two and one-half inches in diameter, be conducted to a limited inductive circuit, the light will appear as a beautiful sunset pink; but if additional electrodes be placed each two feet from the ends of the tube, and they are connected to the vibrator, the light between them is now changed to a beautiful white; showing that the greater the agitation of a given volume of rarefied air, the whiter the light.

It was found that the light of the small spark in the vibrator envelope had no effect on the light in the electrodeless tubes, and that neither did the light from the spark of one vibrator in any way affect the working of other vibrators in close proximity to it.

Since these tubes can be bent into almost any design, I have constructed a complete alphabet which can be used to spell out attractive signs. In this sign I have arranged the letters to compose the sentence "Let there be Light." It is not a stereotyped form of sign, however, since the letters are so constructed that they can easily be removed, enabling one to change the sign at will.

The letters, being so simple, cost but a few cents apiece. Such a sign, equipped with its small magnet and vibrator at its back, can be attached with a flexible cord and plug to any incandescent lamp socket, and the consumption of current necessary to light the sign is very low. The sign can also be made adjustable to any size of letters. The first electrical sign was probably constructed in 1881; the latest, as you see it. Here is a sign with letters but five-eighths of an inch high, suggesting that some sprite has dipped its pen in sunlight and written the words.

This association, that it is my privilege to address, will in the future never have to change its name, but it will change its methods of furnishing light. In fact, the initial step has already been taken in the glowing characters N. E. L. A. It has been suggested that these letters may possibly indicate something analogous to the ominous handwriting on the wall witnessed by Belshazzar in times gone by. The quality and purity of the light emitted from these illuminated letters beggar description. It should be noticed that each letter has a different tint, yet the entire effect is exceedingly harmonious. They are not composed of a number of costly incandescent points or flaments, but of a continuous stream of the softest and most mellow light imaginable.

If the light in these tubes or letters were due to the action of the discharge from the negative electrode upon the surface of the glass, thus causing it to really phosphoresce, it might then be properly called phosphorescent light. But, since the glass plays a very insignificant part in the production of the light, and since the light seems to be due to the action of a high potential electrode (whether positive or negative) discharging through a gas, it is apparent that the name is not applicable. That the polarity of the high potential pole is of little consequence, is strikingly shown in the letters N. E. L. A.; that is, reversing the poles of the letters does not affect the light in the slightest; neither in color, nor in the way it makes short cuts around the corners of the letters. But all of the peculiar light that you have seen this evening is due to the vacuum gap, or, as it is sometimes called, the ether gap, in the small tube enveloping the vibrator; hence the name "Etheric Light."

Aristotle, in the fourth century before Christ, introduced a fifth element—ether; air, earth, water and fire being the other four. Although we now realize that his idea of the elements was very meagre, his term ether remains, and grows in importance every day. It is a thin substance, without weight, which permeates all space, and which transmits light vibrations very rapidly.

The problem heretofore has been to get a practical intensity of light from a vacuum tube, regardless of the method pursued or its economy; but since this result, through the agency of the vacuum vibrator, can now be obtained, the main problem has now resolved itself into one of economy. I am happy to say, however, that even here the vacuum vibrator shows an enormous advance over all other methods heretofore used; in fact, from comparative tests between the lighting by incandescence and by tubes of the hall of the American Institute of Electrical Engineers, it was shown that the efficiencies of the two systems do not differ greatly from each other. This is a remarkable statement, in view of the fact that heretofore their efficiencies were almost incomparable, and, secondly, that tube lighting is most decidedly in its embryonic state.

But, not only are these colors pleasing to the eye, but they are also very interesting from a scientific standpoint. The actinic value of this light is very high. A photograph taken of this sign by its own light was very good, but it was noticed that the letters that were the purest white on the photograph were those of the purple and crimson hue in the sign. Further investigation may prove that light of this kind may be far more serviceable in photogravure work than the arc lamp is at present; and also that the best of portrait photographs may hereafter be taken independently of daylight.

When this method of lighting is more fully developed, we shall indeed have beauty and brilliancy without glare, and a slumbrous light, rich with delicate shades of color that make it admirably fitted to harmonize with drapery, foliage or decorations of any conceivable style. Think how different this will be from incandescent lighting. Æsthetic lighting is now interfered with because many forms of partially opaque glasses are used to screen the painfully brilliant "hairpin of fire." Of course, nothing of this kind will be thought of with the new light, because there is nothing objectionable to conceal; but, on the contrary, the source of light, being of great area, will always be an object of beauty.

Although the new year was not ushered in by floods of etheric light, making all around as brilliant as the sun in his zenith, nevertheless, the dawn gives hope of the noonday glory, and is the harbinger of the coming day.

ORDER OF BUSINESS

THURSDAY, May 7th, 1896

FIFTH SESSION, 10.35, A. M.

1. REPORT. Finance Committee. JOHN A. SEELY, Chairman
2. REPORT. Committee on Data. H. M. SWETLAND, Chairman
3. Topic—"A Standard Socket." By MR. ALFRED SWAN
4. Paper—"The Evolution of the Arc Lamp." By L. H. ROGERS
5. Paper—"Electrolysis." By CAPTAIN WILLIAM BROPHY
6. Announcements

SIXTH SESSION, 3.10 P. M.

1. Paper—"Steam Boilers, Their Equipment and Management." By ALBERT A. CARY
2. Executive Session

FIFTH SESSION

The president called the meeting to order at 10.35 A. M.

MR. ARMSTRONG: I move that a committee of five be appointed to make nominations for officers for the ensuing year.

Carried.

The president appointed the following-named gentlemen as such committee: Messrs. Armstrong, Leslie, Francisco, Giles and Huntley.

The following communication was read:

JUBILEE OF THE RIGHT HONORABLE PROFESSOR LORD KELVIN

SIR: In the autumn of this year the Right Honorable Lord Kelvin completes the fiftieth year of his tenure of the Chair of Natural Philosophy in the University of Glasgow. An event so rare in academic history naturally calls forth the heartiest congratulations of the university and the city; but, in view of his pre-eminent position as a man of science, it has been thought fitting that other bodies who have already testified their appreciation of Lord Kelvin's distinction by enrolling his name among their members, should be invited to take part in the proceedings with which it is proposed to celebrate the Jubilee of his Professorship.

We are desired by the committee charged with the arrangements to intimate that the university and the municipality would be gratified by your appointing a representative to take part in the celebration to be held here on the 15th and 16th of June next. Be so good as to send Professor Stewart, Clerk of Senate, The University, Glasgow, not later than April 10th, the name and address of your representative, in order that a formal invitation may be forwarded to him.

We have the honor to be, sir, your obedient servants,

JOHN CAIRD,

Principal and Vice-Chancellor of the University.

JAMES BELL, Bart.,

Lord Provost of Glasgow.

The Secretary National Electric Light Association of New York.

THE PRESIDENT: As this was a matter that required a prompt reply, I took it upon myself to appoint Mr. T. Commerford Martin, who will be in Glasgow at the time, to represent the association. I think, however, that it would be in order for the convention to ratify the appointment; and I would also suggest that a motion be made to have a set of resolutions engrossed, appointing a committee for that purpose, to be tendered to Lord Kelvin by our representative.

MR. ARMSTRONG: I move that the action of the president be approved, and that Mr. Martin be confirmed as our representative on this occasion. I make the additional suggestion that Mr. Martin be requested to convey to Lord Kelvin the resolutions to be prepared.

Carried.

MR. SEELY: I move that Mr. Martin be authorized to prepare the resolutions.

THE PRESIDENT: I think a small committee would be enough, and Mr. Martin can do this very well.

Mr. Seely's motion was carried.

The President: I think, Mr. Seely, that we should like to hear the report of the Committee on Finance.

Mr. Seely: *Mr. President, and Members of the National Electric Light Association:* The Finance Committee respectfully submits the following report:

National Electric Light Association, Financial Report For Year 1895

RECEIPTS

Active membership dues for 1895	$2,550 00	
Associate " " 1893	20 00	
" " " 1894	40 00	
" " " 1895	1,820 00	
" " " 1896	20 00	
		$4,450 00
Sale of Report of Eighteenth Convention	350 00	
Sale of Badges of " "	140 00	
Sale of Publications	26 67	
Advertisements in proceedings	970 00	1,486 67
Total receipts		5,936 67
Balance in Bank January 1, 1895	539 09	
Balance in Petty Cash January 1, 1896	9 65	548 74
		$6,485 41

DISBURSEMENTS

Salary of Secretary	$2,000 00	
Rent	208 32	
Printing and Stationery (including proceedings and papers read at meetings)	2,002 53	
Sundry expenses	41 15	
Stenography and typewriting (including report of convention)	832 42	
Badges	115 54	
Postage and telegrams	177 64	
Traveling expenses	369 13	5,746 76
Balance January 1, 1896		$738 65
Balance in Bank January 1, 1896	$716 90	
Balance in Petty Cash January 1, 1896	21 75	
Net Balance		$738 65

ASSETS

Cash as per above statement..........	$738 65	
Cash in hands Finance Committee..........	889 29	
Office Furniture, as appraised by Finance Committee.	165 00	$1,792 94

LIABILITIES

None

Respectfully submitted,

J. A. SEELY,
E. F. PECK.

DISCUSSION

MR. SEELY: I may say that the amount referred to in the report as being in the hands of the finance committee is the balance due the association on our last exposition, at Montreal. The chairman of the committee now stands ready to turn the money over to the treasurer, as all accounts have been closed. A part of this fund was a donation made to the association, but for a long time we were unable to accept it, as the matter had not been properly closed up; but that has now been done, and we are enabled to accept that donation, which brings it up to $889.29. We have to-day cash and assets of $1,792.94. This does not include the dues for 1896, a large part of which have been paid at this meeting. This is only the report for the year 1895. We have been charging off ten per cent on our office furniture every year, and we have reduced our furniture to $165. There are no liabilities. We do not owe a dollar.

MR. ARMSTRONG: I move that the report be accepted.

Carried.

MR. BEGGS: I should like to suggest the advisability of the report of the finance committee being brought hereafter to a date much nearer our annual session. This report, as you have heard, brings the business of the finance committee down to the first of January.

There may have been some reason for that when the annual meetings were held in February of each year and we had semi-annual sessions; but I think it would be well that their report should be brought down as close to the time of the annual meeting as possible, so that we may know what the affairs of the association are at that time, and not on January 1st. A large amount of dues have been received in the past four months, no doubt, and we should have them included. I make this as a suggestion, and not in the spirit of fault-finding. I do not know whether or not there is anything governing the time when the committee shall make its report, and if there is not anything, I desire that something shall be done, either by the finance committee itself or by the association.

MR. SEELY: I agree with Mr. Beggs on that point, and, in fact, I had suggested that we include in our report the funds that came in up to date. There are a number of active members that never pay their dues until they come to the convention, and it has occurred that the executive committee of this association has found it necessary to advance sufficient funds to carry the association along until after the annual meeting. If the members would pay up promptly, we should be in a position to make the report include the payments up to date. I thoroughly agree with Mr. Beggs on this subject.

MR. ARMSTRONG: I presume the committee would really follow out that plan without any instructions, except, I suppose, that all the dues paid now are actually dues for the coming year, and would not properly be included in that report. As I understand, that money is in the hands of the secretary, to be turned over at the beginning of the year that we are about to start. The only point to be considered in the matter is that there might be a large number of expenditures from January 1st to May 1st, which ought to be charged in the finance committee's report, because all back of that is practically the past year.

The past year, instead of being twelve months, should have been fifteen months, so the report ought to be brought up to, say, the last of March, or, if possible, the last of April. I think the suggestion of Mr. Beggs is a good one to govern the committee hereafter, and I presume it doesn't require anything more than a suggestion.

MR. BEGGS: I think it is within the province of the committee.

THE PRESIDENT: The committee can act upon the suggestion.

MR. DE CAMP: Our fiscal year is provided for in our by-laws from January 1st to January 1st; it would, therefore, be necessary to change that rule.

MR. NICHOLLS: We could have the regular annual report, with an appendix showing the state of finances up to the date of the meeting.

MR. DE CAMP: If it is recognized as an appendix, it should not go on the report for the fiscal year, because it becomes confusing. I think, however, that it is perfectly proper and desirable that the members be informed as to the finances of the association up to as late a date as possible.

MR. ARMSTRONG: I do not think there is any time mentioned for our fiscal year.

MR. SEELY: If the report had been made up to date, the finance committee would have been able to add to this report the two thousand dollars that the Exposition Company has paid the association; and, probably, about two thousand dollars more in dues that have been collected in the past two weeks, which would have made our balance for 1895-6 about $4,792 04.

MR. BEGGS: I think the whole matter is one worthy of careful consideration by the executive committee itself, or some committee that may be appointed to revise the by-laws in view of the very radical changes engrafted on our by-laws at Cleveland, covering the meetings of the association. For this reason, I think our fiscal year should be changed, and should extend from one meeting until the next. For instance, if a member, either active or associate, became a member of the association at the last annual meeting, in Cleveland, in February, 1895, their membership really ceased on the first of January, according to the present law. I do not think that is fair to them, nor the intent of the association. I think membership should be for the fiscal year—from one annual meeting to the next.

I made this suggestion to show the necessity of some general modification of the by-laws, because of the action that did away with semi-annual meetings and changed the time of the annual meeting. When we met in February, the first of January was, of course, sufficiently near to make the current calendar year the fiscal year of the association. It is a question whether the whole by-laws should not be revised, to make them meet the conditions existing to-day. They do not say anything at all about the change in the time of meeting. We should have our printed by-laws conform to what they are and what they ought to be; otherwise, we are at sea. I believe in bringing the reports of all committees down to the date of meeting.

MR. FRANCISCO: At the time of the Cleveland convention, the constitution was changed, and the time of holding the annual meeting was made May or June. It was understood that the fiscal year was to be changed to conform to that, so that this convention should be the closing of the fiscal year of the association. It was carried, although no change has been made in the printed form.

MR. BEGGS: Could we have from the secretary a copy of what was really adopted, and see whether any changes are necessary? I did not understand it to be so definitely fixed as you state.

MR. FRANCISCO: I do not know whether it is in the manuals, but the change was made at that time.

(Note—Mr. Francisco was in error in regard to this. There was no discussion at Cleveland in regard to a change in the fiscal year, and no change was suggested or made.)

MR. NICHOLLS: Following out Mr. Beggs' suggestion, as I understand there can be no change made in the by-laws without notice of motion having been duly given ahead of time, it might be advisable for Mr. Beggs to give notice of motion to refer the matter to the executive committee, and that they bring in a report at the next convention suggesting certain changes in the by-laws.

MR. BEGGS: Do I understand that this association is powerless to correct its laws at this session?

THE PRESIDENT: No; the association can alter the by-laws at the present meeting.

MR. BEGGS: I move that the matter be referred to the executive committee to examine what was done at the Cleveland meeting and report such changes in the by-laws as may be necessary to conduct our business. It is due to both officers and members that we should know the exact condition of affairs at the time of the meeting.

MR. FRANCISCO: I will read this section of the constitution:

Section 2. No amendment shall be voted upon by the association at the convention in which it is introduced.

THE PRESIDENT: That was amended. The present constitution provides that it can be done.

MR. DE CAMP: I should like to know when the constitution was altered.

MR. ARMSTRONG: The records will show all about this. I will read the following from the report of the Cleveland meeting:

"*Mr. Armstrong:* I offer this as a substitute for the amendment to the amendment: *Section 2. Any amendment may be voted upon at the convention at which it is introduced, unless objection is made by five active members.*"

The last amendment was put and carried, so we can amend our by-laws in any particular at the meeting at which the amendment is introduced, unless five active members object.

A little further on is the following:

"*Mr. Seely:* I offer the following amendment to the constitution and by-laws: *All meetings of this association shall be held in June or July;* and strike out the words 'and a semi-annual meeting may be held in August.'

"*Mr. Nicholls:* I suggest that the months be made *May or June.*

"The amendment was carried, reading *May or June.*"

The constitution, as it now stands, provides that our officers take office on the first of the month succeeding their election. Those we elect here to-day will, therefore, take their office on the first of June. If, by action of the executive committee, our next meeting should be held in June, the fiscal year will not end until the thirteenth day of June, and the next fiscal year will begin on the first of July.

It is unfortunate that we have not had the by-laws printed as amended; but the amendments have been made broad enough to cover any possible question, without any further action, and the suggestion made by Mr. Beggs, as to the starting and ending of our fiscal year, need be, so far as the finance committee are concerned, no more than a suggestion, because our constitution practically provides that way.

MR. BEGGS: When membership has been acquired at a particular meeting, and dues paid at that time, according to the law just read by Mr. Armstrong, the rights of a member technically cease after the first day of June. They have simply paid dues for the fiscal year. My idea is that the law should be changed, and that the officers and executive committee elected to-day take their offices and begin their terms of service after the close of this meeting. They should continue from one annual session until the next, and the dues should carry membership from one annual meeting until the next. According to the law read by Mr. Armstrong, the officers and executive committee of this association have no right to recognize the membership of any of us beyond the first of June. The membership of every member then ceases, according to that law. That is the end of the fiscal year, and I do not see how any other construction can be placed upon it.

We are not here to find technical flaws in the law, but I believe in making them provide for the conduct of our affairs upon good business lines. My suggestion would be that it is highly necessary that these laws be carefully gone over and made to harmonize with the new conditions. The new officers should take hold of the affairs of this association immediately at the close of this meeting, and not allow an interim between the close of the meeting and the time when they assume the duties of their offices. Our annual dues should also be paid from one annual meeting to the next.

THE PRESIDENT: I suggest that a simple way to remedy that, would be to make the fiscal year end on the first day of the month previous to the meetings.

MR. BEGGS: Make it close at the convention.

MR. BURLEIGH: I would ask Mr. Beggs if he means that the dues paid at the beginning of the session should cover the whole of the next year?

MR. BEGGS: Up to the next session; and the dues must be paid at the next session to entitle the members to participate in the meeting.

MR. BURLEIGH: That is not our law.

MR. ARMSTRONG: Annual dues paid at the last meeting would run up to the first of June. Let them run either to the first of January or the first of July.

MR. BEGGS: I beg your pardon; it would have ended on the last of the calendar year.

MR. ARMSTRONG: I think not.

MR. BEGGS: Very well; suppose they were paid at Cleveland, would they not end on the first of January?

MR. ARMSTRONG: I will read an extract from the constitution covering that point:

"Members in arrears for dues shall not exercise the privileges of membership. Any member in arrears for one year's dues shall be dropped from the rolls, and if he is reinstated he shall pay his dues for the year in which his membership lapsed."

A member might even be in arrears until this meeting, when the payments are made; but a company does not cease to be a member here until some action is taken by the body. It is not the payment that makes the member, but the membership incidentally requires us to pay dues.

MR. BEGGS: I contend that the meetings and the payment of dues shall be co-existent; that the membership should carry from one annual meeting to the next, and the dues should cover the same period.

MR. DE CAMP: If you will consider why the fiscal year was fixed for one date and the time of the outgoing of the officers for another, you will see that there was good reason for it. Of course, the fiscal year was fixed for the calendar year, our meetings, being held in February and our dues being paid in advance. The idea was this: that previously to the first of January the notices would be sent out, with a view to collecting the dues for the coming year, and we rightfully assumed that they would be paid in advance and that the secretary would have in his hands all the money that was due from the present membership, for the coming year. Any receipts he had after that, provided the dues were all paid in advance, would be solely from new memberships; and this arrangement would give him the intervening month between that time and the date of the meeting in which to settle up and make his reports complete.

The date of the commencement of the year for holding office was fixed at the beginning of the month succeeding the election, in order to give the old officers time to fix up things in proper shape for their successors. It was not thought to be proper to throw upon the incoming officers the burden of arranging the matters incident to the meeting at which they were elected. I think that is right.

If you make the beginning of the fiscal year come nearer to the date of the meeting, it makes it better; but a month intervening is not too much, because you must remember that the officers of the association do their work while here, and they have to do it in a short time, and the month intervening is a proper time for doing it. So far as membership is concerned, a man pays for one year, and as we have only one meeting in each year he gets the benefit of that meeting. There is no doubt about it.

THE PRESIDENT: If there is no objection, I think this matter should be referred to the executive committee, and they can make any change they deem proper.

MR. DE CAMP: I move that the subject be referred to the executive committee with power to act.

Carried.

THE PRESIDENT: I will name as a committee to confer with the American Institute of Electrical Engineers for the purpose of determining a standard candle power for incandescent lamps, Dr. Louis Bell, chairman; Mr. James I. Ayer and Mr. Louis A. Ferguson.

THE PRESIDENT: I will appoint as the Committee of Five on Standard Rules for Safe Wiring, which is to select one of its members to meet the gentlemen in the conference on Standard Rules for Electrical Installation, Captain William Brophy, chairman; Messrs. C. R. Barnes, William J. Hammer, James I. Ayer and C. L. Edgar.

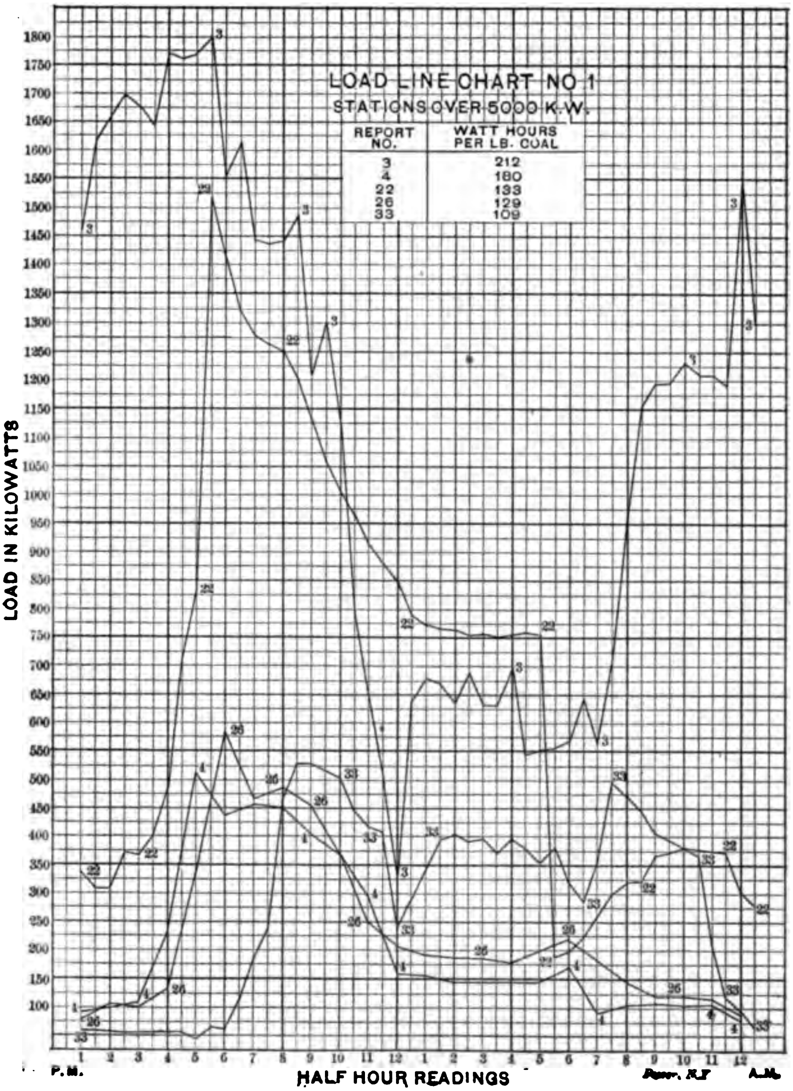
THE PRESIDENT: The next business before the meeting is the report of the Committee on Data.

Mr. Swetland, chairman of the committee, read the following report:

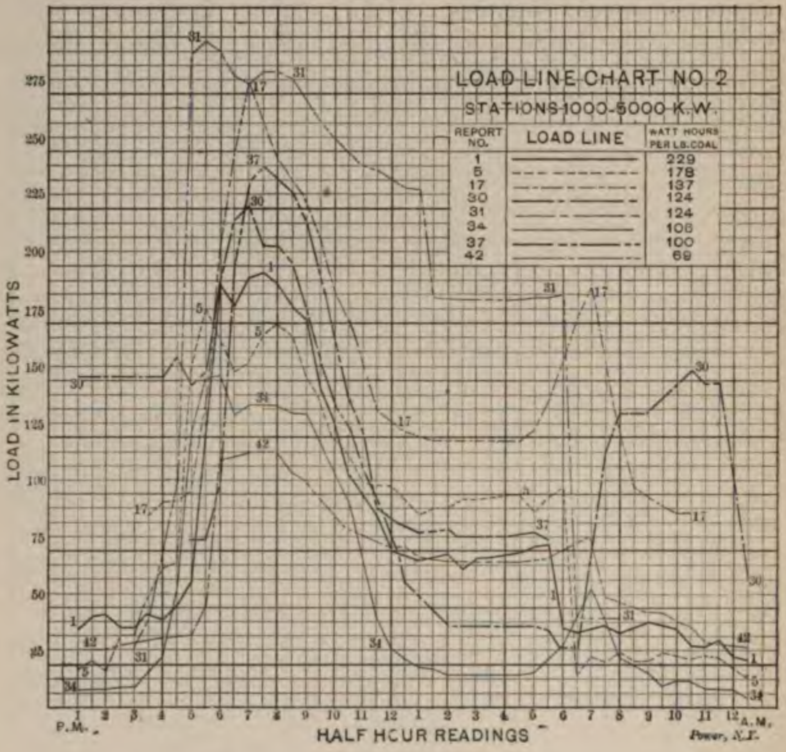
REPORT OF THE COMMITTEE ON DATA

Mr. President:

Your committee is able to present a tabulated statement of watt hours produced per pound of coal from eighty-two central stations using coal as fuel, and from one using crude oil, and are able to show the class of equipment from all boiler tests from thirty-two, and engine efficiency from eight. Thus far, the work has been carried forward on the lines of the previous reports by this committee. In addition to this, we have been able, from the information furnished, to construct load lines from twenty-two of the stations reported, the lines being presented on charts 1, 2 and 3, submitted herewith, each line being numbered to correspond with the number of the report. Economies are given from a number of the largest electric stations in the country, five of them having an output of over 10,000,000 watt hours per day, and forty-five having an output of one to ten million watt hours per day. Four of the large stations represent a production of 94,270 kilowatt hours and a consumption of 524,667 pounds of coal, or 179 watt hours per pound of coal. The aggregate output of these forty-nine large stations reaches the production of 212,617 kilowatt hours in one day at an expense of 1,316,703 pounds of coal, or an average of 161 watts per pound of coal. The aggregate output of thirty-two smaller stations, those producing less than 1,000,000 watt hours per day, represents a production of 11,973 kilowatt hours with an expendi-

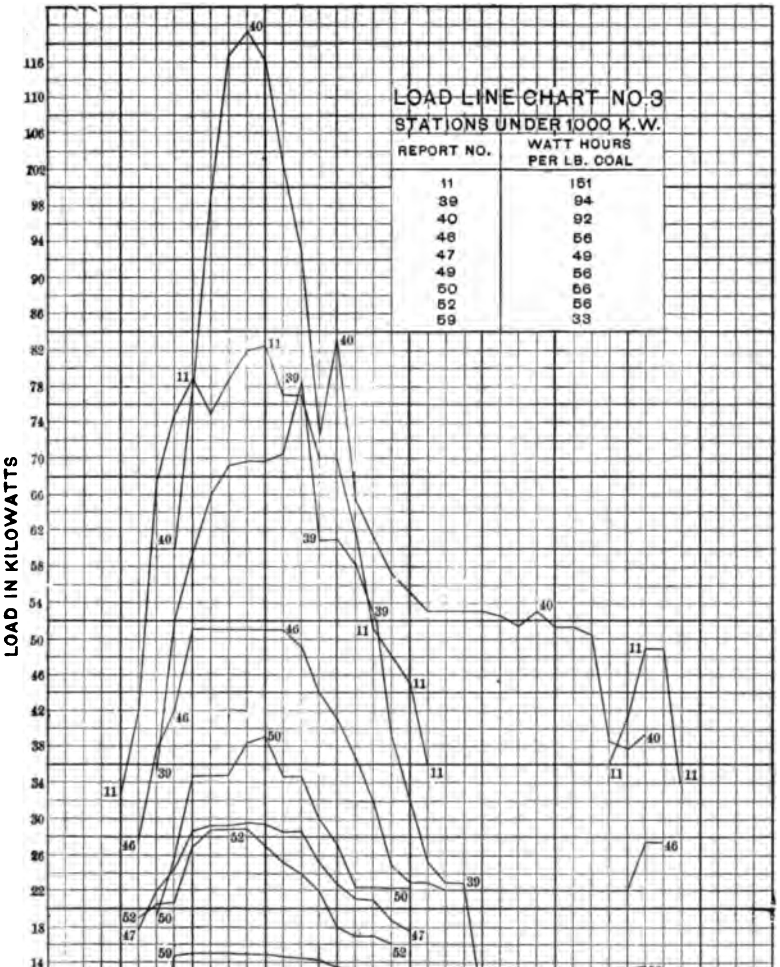


ture of 194,274 pounds of coal, or sixty-two watts per pound of coal. The aggregate electrical output of entire report, several stations having reported for a long period, in one case (report 6) for one year, represents the generation of 4,618,976 kilowatt hours at an expense of 28,274,536 pounds of coal, or an average of 164 watt hours per pound of coal. The average efficiency of the eighty-one reports using coal as fuel, is 108 watt hours per pound of coal; one report, giving the production from crude oil, shows 1,717 watt hours per gallon of oil.



Power, N.Y.

The load lines shown in the charts have been constructed from thirty-minute readings from meters or estimated from voltage and amperes. The committee realize that in the case of alternating currents the product of amperes times volts may not give the



REPORT NO.	WATT HOURS PER LB. COAL
11	151
39	94
40	92
46	56
47	49
49	56
50	66
52	56
59	33

absolute watts, but this method has been considered sufficiently accurate for this work, and has been used in a few instances. The minor points called for in the information blank sent out by the committee, relative to evaporation per pound of coal, water used in the engines, calorimeter tests, etc., have not received very general attention, although simple directions were given for this work. The thirty-one stations reporting the water evaporated per pound of coal, show a wide range of boiler efficiency, not to be accounted for by the difference in quality of fuel. Report No. 81 evaporates 10.5 pounds of water per pound of semi-bituminous coal, comparing favorably with report No. 8, each using horizontal tubular boilers; while report 67 evaporates only 4.66 pounds of water per pound of bituminous coal with the same style of boilers; the average evaporation per pound of coal from all stations giving reports being 7.09. In engine efficiency, eight stations report the water consumption per indicated horse-power. The triple expansions lead in economy, report 80 showing a consumption of fifteen and one-half pounds, and report 3 showing eighteen pounds of water per indicated horse-power; these comparing reasonably with report 29, where an indicated horse-power is produced by non-condensing engines with twenty-six pounds of water. Report No. 22 in the Table of Economies, submitted at the last convention, showing a production of 262 watts per pound of coal, and having the highest economy in the stations mentioned in that report, is from the same station as report No. 3 in the present table, and which, in point of economy, stands third on the list, the economy being 212 watts per pound of coal, a showing somewhat inferior to the previous report. The station is reported in a general way as running at greater economy than when the previous report was made. The efficiency figures, however, would seem to contradict this statement, and to verify the statement in the present report. In the previous report, 9.37 pounds of water were evaporated per pound of combustible, and seventeen pounds of water consumed in the engines per horse-power. The present report brings the evaporation per pound of combustible down to 8.81 pounds of water, and the steam consumption in the engines is raised to eighteen pounds, which would account for the lower efficiency stated in the present report.

Attention is called to the reports from plants running with non-condensing engines, in which report 26 (see load line) is able to show 129 watt hours per pound of coal; report 32 (see load line), 113 watt hours; report 33, 109 watt hours; report 37 (see load line), one hundred watt hours; and report 38, ninety-five watt hours; while Nos. 39 (see load line), 43, 59 (see load line), 68 and 71, running condensing, produce, respectively, only ninety-four, sixty-eight, thirty-three, seventy-eight and eighty-seven watt hours; this showing, and other features of the report proving, conclusively, that it is as much a question of management and manipulation as of the type of machinery used.

In conclusion, we are led to repeat a former statement by this committee, that the economy secured in generating power for electrical work does not compare favorably with the production of power for other purposes, and that this is also true after taking into consideration the variation in load due to electrical work. Referring to a recent statement of the economy of the Chestnut Hill pumping station at Boston, it was found that in actual water lifted a horse-power was produced by the consumption of 1.34

pounds of coal; allowing that the efficiency of pumps compares favorably with efficiency of the generators, and making no allowance for variation in load, one pound of anthracite coal used with the same economy in electrical work should produce 557 watt hours. Our load line charts show a fair average of the variation in electrical work, line 3, chart 1, dropping from 1,800 kilowatts at 6 p. m. to 250 kilowatts at midnight; yet the changes seem, as generally true in electric lighting, to be fairly uniform, and a station planned with the proper units for the work should operate the much larger percentage of its generating appliances on a fair basis of economy, bringing the record in this work much nearer the standards of efficiency in other lines. We advise more careful records, more frequent tests of all apparatus, and a steady application of principles of economy, until this record can be made to show more favorable comparison.

Committee on Data,

H. M. SWETLAND, New York, Chairman.
E. L. POWERS, Chicago, Ill.
J. A. VAN ETTEN, Little Rock, Ark.
HOWARD W. SEXTON, Anniston, Ala.
A. W. FIELD, Columbus, Ohio.
J. A. COLBY, Des Moines, Iowa.
JAS. R. DEE, Houghton, Mich.
JAS. I. AYER, New York, N. Y.
C. R. VAN TRUMP, Wilmington Del.
G. F. BROWN, Nashville, Tenn.
W. R. GARDENER, Pittsfield, Mass.
W. D. DICKINSON, Great Falls, Mont.
E. E. WADE, Coloradó Springs, Colo.
H. T. EDGAR, Atlanta, Ga.

TABULATED REPORT FROM ELECTRIC LIGHT STATIONS; SHOWING WATTS PER POUND OF FUEL, EQUIPMENT, EFFICIENCY, ETC.

No. of Report.	Hours in Run.	Watt Hours, One Day.	Coal Used, One Day. Lbs.	Watt Hours Per Lb Coal.	Fuel—Kind and Grade.	Equipment. (See Foot Notes.)			Boiler Test. Evaporation			Engine Test. Water per hour per I.H.P.	No. of Report.
						Engines.	Boilers.	Dynamos	Per lb. Coal.	Per lb. Combustible.			
										Actual.	From and at 212°		
1	24	3207392	11600	237	Bit. Lump.	D	C	V	6.2	6.87	7.12	—	1
2	24	2397712	11251	213	Bit. Lump. [Screenings.	D	C	V	5.7	6.45	6.69	—	2
3[1]	24	26402256	124383	212	½ Ea. Soft Coal and Hard	A	A	A	7.38	8.81	10.22	18.	3[1]
4[1]	24	5053166	28050	180	½ Anth. ½ Pea and Dust.	B	1A, 5C	B	8.91	—	—	36.9	4[1]
5[2]	24	1818780	10200	178	.4 Coke .6 Coal.	CD	C	V	5.4	5.75	6.41	27.6	5[2]
6	24	11488509	65884	174[4]	Bit. Run of mine.	BDz	C	V	—	—	—	—	6
7	24	1212900	7105	171	" " "	B	C	V	—	—	—	—	7
8	24	825000	5022	164	Bit. and Hard Screenings.	Ex	C	V	10.35	11.48	—	—	8
9	24	4270077	26600	161	½ Anth. ½ Dust and Pea.	B	1A, 5C	V	9.17	—	—	42.2	9
10	14	1718000	11400	151	Bit. Va.	BC	C	V	—	—	—	—	10
11[3]	15½	8600	5500	151	" "	CD	A	Alt.	—	—	—	—	11[3]
12	24	2156000	14493	149	Buckwheat.	3C, 1E	C	Alt.	8.99	10.34	11.23	—	12
13	14	1625000	11440	142	Bit.	BC	C	V	—	—	—	—	13
14	16½	711720	5100	140	Bit. Slack.	D	C	V	—	—	—	—	14
15	16½	727720	5200	140	Bit.	D	C	V	—	—	—	—	15
16	14	1624000	11840	137	Bit. Run of mine.	BC	C	V	—	—	—	—	16
17[3]	14	2734976	19900	137	Slack.	Dx	B	V	8.25	8.9	9.43	—	17[3]
18	14	2599705	19050	136	Slack.	Dx	B	V	7.92	9.35	9.9	—	18
19	14	1526000	11200	136	Bit. Run of mine.	BC	C	V	—	—	—	—	19
20	14	1560000	11600	134	" " "	BC	C	V	—	—	—	—	20
21	14	2722463	20650	134	Slack.	Dx	B	V	7.8	8.8	9.39	—	21
22[1]	24	16149010	121400	133	Slack and Bit.	B	C	V	—	—	—	—	22[1]
23	16	1528100	11595	131	Bit. Lump.	D	C	V	—	—	—	—	23
24	15½	695720	5300	131	Bit.	D	C	V	—	—	—	—	24
25	16	1549100	11860	131	Bit. Run of mine.	B	C	V	7.7	8.3	—	—	25
26[1]	24	5401900	41924	129	Semi-Bit.	EDx	BC	..	9.5	12.2	—	30	26[1]
27	14	1399000	11200	126	Bit.	BC	C	V	—	—	—	—	27
28	16	1568600	12000	131	Bit. Lump.	B	C	V	7.7	8.3	—	—	28
29	13	2103800	16800	125	Anth. Buckwheat.	Cx	C	C	6.84	8.26	8.73	26	29
30[2]	24	2683008	21571	124	Bit. Nut and Slack.	Ex	AC	Bi.P.	—	—	—	—	30[2]
31[2]	17½	3396619	27414	124	....	—	—	—	9.8	9.8	—	—	31[2]
32[2]	24	1763795	15625	113	½ Ea. Bit. and Anth.	EDx	C	B	8.93	10.57	11.02	—	32[2]
33[1]	24	6794304	62504	109	.6 Anth. 4 Bit.	Ex	6C, 5A	BE	—	—	—	—	33[1]
34[2]	24	1193876	10475	106	Anth. Buckwheat.	4C, 1E	C	C	—	—	—	—	34[2]
35	24	1074436	10250	105	" "	4C, 1E	C	C	—	—	—	—	35
36	—	160049988[5]	1533000	104	Bit. Screenings.	BC	AB	—	—	—	—	—	36
37[3]	12½	2202363	22080	100	Lignite, Run of mine.	BDx	AC	Alt.	4.8	5.2	—	—	37[3]

41	—	268800	2896	92	" "	Ex	C	C	—	—	—	—	41
42²	24	1444931	20800	69	Slack.	Ex	. BC	BC	6.33	—	—	—	42²
43	6½	93541	1365	68	Buckwheat, Anth.	E	C	C	—	—	—	—	43
44	8	230187	3600	64	....	Ex	C	B	—	—	—	—	44
45	14¾	310928	5000	62	Bit.	Ex	C	V	—	—	—	—	45
46³	15	254745	4520	56	Bit.	Dx	C	C	—	—	—	—	46³
47²	7½	186412	3810	49	Slack.	Ex	C	B	—	—	—	—	47²
48	24	66285375⁵	1160500	57	Bit.	1D, 2Ex	A	C	—	—	—	—	48
49³	14	156800	2800	56	Bit. Run of mine.	Ex	C	C	—	—	—	—	49³
50³	7½	214485	3900	56	Bit.	Ex	C	B	—	—	—	—	50³
51	7½	204435	3600	57	Bit.	Ex	C	B	—	—	—	—	51
52³	10	6453491⁵	116000	56	Bit. and Slack.	Cx	C	Alt.	—	—	—	—	52³
53	7½	217228	4000	54	Bit.	Ex	C	B	—	—	—	—	53
54	7	221250	4200	53	"	Ex	C	B	—	—	—	—	54
55	7½	186412	3810	49	Slack.	Ex	C	B	—	—	—	—	55
56	7	208535	3900	53	Bit.	Ex	C	B	—	—	—	—	56
57	6	161458	3150	51	Bit.	Ex	C	B	—	—	—	—	57
58	7½	174928	3720	47	Bit.	Ex	C	B	—	—	—	—	58
59³	15	203555	6200	33	Anth. Buckwheat	Ex	C	V	—	—	—	—	59³
60	14	762825	20700	37	Bit. Slack.	Exy	C	V	5.44	—	—	—	60
61	15½	806880	19300	42	" "	Exy	C	V	5.78	—	—	—	61
62	18	1294708	31040	42	" "	Ex	C	V	4.23	—	—	—	62
63	16½	866235	20500	42	" "	Exy	C	V	5.75	—	—	—	63
64	14	1454656	31739	46	Bit. No. 2 Nut.	Cx	B	V	5.48	6.5	6.85	—	64
65	14½	1881102	31992	59	" "	Cx	B	V	5.8	7.1	7.48	—	65
66	24	194472	3300	65	Wilmington Lump.	(1E, 7C) x	C	C	—	—	—	—	66
67	8	444133	6101	73	Bit. Slack.	Ex	C	V	4.66	—	—	—	67
68	14	1201483	15386	78	Bit.	C	C	Alt.	—	—	—	—	68
69	10	506697	6296	80	Bit. Slack.	Ex	C	V	5.59	—	—	—	69
70	24	5982000	71000	84	Bit. Screenings.	(6D1E5Dz)x	A	V	—	—	—	—	70
71	14½	1243441	14224	87	Bit.	C	C	Alt.	—	—	—	—	71
72	14	477425	5400	88	Semi-Bit.	Ex	C	Alt.	9.68	10.7	11.13	37	72
73	24	2879000	31200	92	Bit. Screenings.	Dxz	A	A	—	—	—	—	73
74	13½	1217000	12895	94	Anth.	Ex	C	V	—	—	—	—	74
75	24	1960973	17600	111	Bit.	Ex	C	V	—	—	—	—	75
76	24	3366065	. 20300	166	½ Ea. Anth. Bit.	B	A	Alt.	6.82	7.89	9.20	—	76
77	24	3373305	20300	166	" "	B	A	Alt.	6.2	7.14	8.33	—	77
78	24	3398595	20300	167	" "	B	A	Alt.	6.6	7.56	8.82	—	78
79	24	40230300	213000	189	Bit. Screenings.	A	A	A	—	—	—	15½	79
80	24	14941089	8700gals	1717⁶	Crude Petroleum	D	2B, 1C.	B	—	—	—	—	80
81	24	3455988	19100	181	Semi-Bit.	(A.D.E)xy	C	V	10.5	—	—	—	81
82	24	5761915	40800	141	3 Slack 1 Nut.	1D, 2B	B	V	—	—	—	—	82

NOTES.—1, 2, 3; See Load Line Chart 1, 2 or 3, the load line bearing same number as report.

4; Average from one years' record.

5; Total for one month.

6; Per gallon of oil.

Equipment Letters denote classes as follows:

A. Engines, triple expansion condensing. Boilers, horizontal water tube. Dynamos, multipolar on engine shaft.

B. Engines, Corliss compound condensing. Boilers, vertical water tube. Dynamos, bipolar, belted from jack shaft.

C. Engines, simple Corliss, or slow speed condensing. Boilers, horizontal tubular. Dynamos, continuous current.

D. Engines, high speed compound condensing, belted direct to dynamo.

E. Engines, simple high speed condensing, belted direct to dynamo.

x. Any of the above non-condensing.

y. Belted to dynamos.

z. Dynamo on engine shaft.

John J. Jennings, Wilkinsburg, Pa.
J. J. Flanagan, Portsmouth, N. H.
A. M. Robertson, Minneapolis, Minn.
Herbert A. Wagner, St. Louis, Mo.
Arthur L. Bosley, Baltimore, Md.

DISCUSSION

Mr. Armstrong: I move you, Mr. President, that the report be received, a vote of thanks be extended to the committee and the committee be continued.

Mr. Swetland: Before that motion is put, as this meeting seems to be a time for having committees discharged, I should like to request that the Committee on Data be discharged. I make the request as a result of a meeting held by this committee at the Murray Hill hotel on Monday afternoon. I think we have carried this work as far as we can by correspondence and under the present arrangement of securing this information. I think we might possibly go on another year and duplicate the work we have done this year; but I do not think it is profitable, and it will not pay for the time spent in the preparation of the matter. It seems to me that the whole matter should be reorganized, and put in different shape, if the committee is to be continued; but I think it is best that the committee be withdrawn and the work reorganized on some other basis. I should like to have the motion to continue the committee so amended that the committee will be discharged.

Mr. Armstrong: From what was said in some informal talk that I heard here, I rise to ask if the work of this committee would not be much more efficient from a practical standpoint if they had a certain number of stations—I do not know how many—which should be selected as sample stations, and such stations examined and investigated by the committee and reported upon. I do not understand that the committee themselves could do it; but could they not employ a competent person, in a clerical capacity, if you choose, and base a report upon the investigations of that person which would give practical information?

I heard some central station managers say that it was almost impossible to get such reports as you wanted, for various reasons given; but if some engineer were sent to this, that and the other station, in a short time what was desired could be returned, and a very practical and helpful report could be made. Not knowing anything at all about the matter, this struck me as being so reasonable and sensible that I thought it advisable to make some such suggestion. Possibly that is what they have in mind. To accomplish it, it would seem to me that the committee ought to be continued, with the understanding that it might, with a limited expenditure, from time to time send and get information that would be of great value in the matter of dollars and cents to our central station members. I apprehend that if a person of sufficient ability were sent out to the various stations that might be selected by a proper committee, and this person should make reports upon them, it would be more efficacious than attempting to collect data from one or two hundred of them and then making an average and taking that for data. Let them be sample stations; the conditions all being ascertained by the same person and the reports made with absolute fidelity; and we should thus have a basis on which our central station men could act.

Mr. De Camp: I am in entire sympathy with Mr. Swetland, who has been chairman of this committee for a number of years. I know it is a very hard thing—almost impossible—to get at what the committee wants,—to get in satisfactory shape what is given to the committee. I think I am right in that, Mr. Swetland?

Mr. Swetland: Yes, sir.

Mr. De Camp: I have not had a chance to look over the report carefully, but I think it demonstrates this very point, because it is not possible for these conditions to exist as stated. The first part of the report, to us who are familiar with watt hours, is all right. But, as I figure it, there are four or five companies that seem to have used 4.17 pounds of coal per horse-power hour, resolving his watt report into the old method of horse-power. There are sixteen of them using 4.63, and sixty-two of them using twelve pounds. That does not seem possible; I do not see how a station could burn it. The report the committee received is certainly wrong.

Mr. Swetland: I think this report, as a whole, compares very favorably with previous reports by this committee. I think the committee will bear me out in saying that a good many stations are running at worse economy than stated by the worst stations in this report. I think this committee can refer to a station where more than fifteen pounds of coal is used to generate a horse-power hour.

Mr. Dow: I had personal knowledge of a station in which the coal consumed was seventeen pounds per horse-power per hour. I was responsible for the operation of the station. It was not due to carelessness, nor bad firing, nor bad coal; but simply bad design, and long hours to run with a load of ten per cent capacity of the engine and boiler.

Mr. Hadley: I will say, for Mr. De Camp's information, that there are quite a number of stations close to coal mines that pay no attention to coal expense, on account of its cheapness; and no attention whatever is paid to the subject of tests until they are requested to make them.

The President: I believe a motion was made that the committee should be discharged. It strikes me that as a national electric light association, we certainly should have a committee doing work of this kind; and, if the present committee is too cumbersome, or cannot get at the information in the way in which they have been working, I would suggest that they consider some other means of reaching the subject; at any rate, we should certainly have a committee that would look into such matters and give us the information.

Mr. Burleigh: Is not this a standing committee, provided for by our constitution?

The President: No, sir.

The original motion is that the report be accepted, and the committee continued.

Mr. Beggs: I agree with the chairman of this committee that it is almost impossible, by the methods at their command, to obtain data of great value to the association generally, or to those running central stations. It seems to me that we could accomplish results that would be of some practical use to us, through the secretary of this association and its executive committee.

I do not believe we need these reports from a great number of companies. What we want, is to get a few representative companies running with each class of apparatus, who we know are running their stations in good shape, and then let the rest try to measure up to that. That is my idea in the working of men; to get the best men to do a certain thing, and then try to have the others work up to them. I believe it is perfectly practicable for the executive committee of this association, or its officers, to make arrangements of this kind with a few companies in various parts of the country. Let us take, for instance, Mr. Edgar's company, the Edison Electric Illuminating Company of Boston, who are getting excellent results; the Chicago Edison Company, represented by our worthy president, and other companies in various parts of the country. Let us take companies using triple expansion engines of the very highest economy, and some that are using non-condensing engines, showing what can be accomplished by good management and modern engineering practice, and what are the results of using different classes of fuel; in this way we could obtain some reliable statistics.

It seems to me that we could get much of this statistical information through our secretary. He is presumably giving his entire time to the service of this association. The executive committee could make arrangements to have certain stations furnish these data, and I do not think there would be any difficulty in getting in that way what we want; and then we should have something to measure up to. I do not want my men to know how these stations burn twelve pounds of coal; I want to know how a horse power can be produced by a pound of coal per hour. It would be of value to every member of this association and to every central station manager.

Mr. Armstrong: I offer the following resolution:

Resolved, That the executive committee be directed to expend such an amount of money as may be necessary to procure data from representative companies, for the benefit of the Committee on Data.

MR. NICHOLLS: Mr. Beggs has referred to the largest and most important stations on the continent.

MR. BEGGS: I intended likewise to include representative stations of different classes; a score of stations, not only different classes as far as the apparatus is concerned, but also as to the load. A small station cannot hope to reach the economy of these large stations that have an output of millions of kilowatt hours. I think we should commence with large stations of certain capacity, and then grade down, so that we should be benefited by the information.

I am not divulging any secrets when I say that some of the large Edison stations all over this country are now monthly comparing notes as to their fuel and other costs per kilowatt hour. My idea would be to take one or two representative stations of that class, and follow down the line, having a score of stations that would be fairly representative of central stations generally. We know that in our small stations—for instance, our station in Cincinnati—we cannot begin to produce power as economically as in the Boston or Chicago station. There are a greater number of stations of the class I am in charge of than of larger ones; but it is necessary to know what can be done when we are operating stations of great capacity; how when we increase the output we decrease the proportionate cost; and we can see what we are to measure up to. That is my whole purpose; to get these general data from a line of stations; not attempting to cover the whole country, because we thereby spread ourselves over too much, and do not get anything of value.

THE PRESIDENT: The question is on the resolution that the executive committee be directed to spend such an amount of money as may be necessary to procure data from representative companies of all classes, for the benefit of the Committee on Data.

MR. BROWNE: I want to offer a suggestion to Judge Armstrong. Instead of making that "from representative companies," strike out "representative," and make it *information to be obtained, if possible, from every company member of this association.*

As I understand the scope of this association, it is for mutual help and educational purposes; and one of the most desirable means of educating ourselves is to call upon ourselves and upon our men to make reports, prepare these data, and in this way they get to know how to accomplish these economies. If Judge Armstrong will not accept the suggestion to strike this out, then I offer the amendment: *That the information be obtained from every member of this association.*

MR. ARMSTRONG: Mr. President, we must learn from experience. Just a moment ago I was reading in the minutes of the last meeting where, after an hour and a half spent on this matter—and the committee had made nearly the same report, with similar criticisms made upon it—before the chairman would again consent to serve, he asked: "Will your company, and your company, make the reports required?" and we undertook to do so. It does not work satisfactorily.

My resolution does not at all preclude the getting of information from every company, but it makes it the duty of some one to see that reports are obtained from certain small and large companies, so that we shall get absolutely full particulars, and the Committee on Data will have something accurate on which to base a report; but it does not at all prevent the obtaining of reports from any others who will make them.

We tried last year to pledge each individual company represented at the meeting. I am told by the committee that, notwithstanding these pledges, the returns were few, and many of the returns were only of a partial nature. If we get returns from twenty small and large companies, the reports to be from the same investigator and absolutely full, errors cannot creep into them, and we can have some basis to work from. I think the resolution will cover all that Mr. Browne desires, as well as the specific object in view.

MR. BROWNE: "Representative" implies exclusion, and my remarks were directed against the spirit of exclusiveness.

THE PRESIDENT: Mr. Browne, your amendment would practically put the work where it has been. That is what we have been trying to do, and have not been able to accomplish; to get accurate reports from all the companies in the association.

MR. BROWNE: I have no objection to the matter being in the hands of one investigator—our secretary—making it his duty to obtain the information, but I trust we can still arouse a spirit among the different companies, members of this association, to prepare the data and send to us. I think it is advantageous to them as operating companies.

MR. ARMSTRONG: I will read from the report of the Cleveland meeting. On page 264, the following is recorded:

"The following resolution of Mr. Ayer was then put and carried:

"*Resolved,* That the secretary be, and hereby is, directed to prepare and send out under the direction of the Committee on Data, suitable blank forms and explanatory circulars for the purpose of enabling the committee to get the best possible results."

This was the conclusion of a great deal of discussion. The report then goes on:

"*The President:* I will ask the central station men present who will comply with this request, to rise."

This was after some quite vigorous remarks and other resolutions, the first of which was:

"*Resolved,* That the Committee on Data be requested and authorized to formulate a set of blanks on which to keep the required data."

That was followed by another resolution on the same subject; and the whole thing was gone over, and fully gone over, after quite a vigorous report.

Mr. Swetland is a very competent sort of a man, but he spoke as if he meant what he said; he is willing to give time and attention to this matter, but he could not do the whole thing if he could not get the reports, and we all felt ashamed about it, and said we would try to do better in the future; and the report to-day is the result of all we then promised.

The resolution offered by Mr. Armstrong was carried.

THE PRESIDENT: I have a letter from Mr. Swan, in which he states that it is impossible for him to be present to open the discussion on the subject of a standard socket. He has sent a typewritten article on the subject, which may be read, and which will no doubt serve its purpose. I think that, owing to the lateness of the hour and the great amount of business before us, we might pass over this paper of Mr. Swan's, and go on with Mr. Rogers' paper on the evolution of the arc lamp.

MR. ARMSTRONG: I move that Mr. Swan's remarks on the topic of a standard lamp socket be printed as having been read.

Carried.

A STANDARD SOCKET

Mr. President and Gentlemen:

The topic that I introduce deals with the vexed question of lamp sockets. Its object is to promote an interchange of opinion on the part of those present that are interested in the subject, and, by its discussion before this convention, give to the question the status which its importance demands.

This question of the standardization of the lamp socket was recently raised by *The Electrical Engineer*, and various letters appeared in that journal on the subject. A notable feature of this correspondence was the preference, almost unanimously declared, for a particular type of socket because of the comparative cheapness of its lamp base.

The fact that a socket outlives many lamps does, undoubtedly, as things now are, encourage the use of that particular type of socket which is usable with the least expensive form of lamp base, though the socket in question may not in itself be the best or the cheapest. This fact would seem clearly to indicate that preliminary to the standardization of the lamp socket must be the standardization of the lamp base. When scientific fitness, due simplicity, and point of lowest cost shall have been attained in regard to the lamp base, then will, necessarily, result a standard socket. Following, therefore, this line of argument, and concerning ourselves first with the lamp base, let us, with due reference to its functions, consider what we should demand in a standard lamp base.

The elements involved in this question are threefold—electrical, mechanical and economical.

Good insulating conditions are of the first importance, to guard against leakage, or other abnormal action, in the wires connecting with the lamp.

Mechanical considerations concern the means by which the base is attached to the lamp, as well as the means by which, when so attached, it couples with the socket; the method of coupling with the latter, while insuring a rigid and unfailing contact, should be such as not to put an undue strain upon the lamp.

Cheapness is, of course, a *sine qua non.*

The death rate in lamps, as compared with sockets, being high, and the base, as a rule, not surviving the lamp, obviously the less value we involve in that base the better.

How many of the present types of lamp base conform to these standard requirements? What could well be more inappropriate to the delicate structure and graceful form of the lamp itself than is even the best—or rather, let us say, the least objectionable—of those appendages with which lamps are now encumbered? In addition to their offending in this respect, they are objectionable in that they involve the use of plaster, which we know is bad, electrically considered. Their large size renders them heavy and clumsy, and all are needlessly expensive, the cheapest costing not less than six dollars a thousand, while I am fully warranted when I assert that one-third of this sum might, and eventually will, provide a suitable and appropriate fitting.

Manifestly, therefore, a standard lamp base must be the first point for determination; a standard not merely accepted as such, but one that by virtue of its essential merits shall be fairly and fully entitled to such recognition; a standard that shall accomplish the nearest approach to finality possible in that direction. Having accomplished that, the rest necessarily follows; a lamp base involves a socket to suit it. Having got the best and the cheapest lamp base that is possible, no other, in time, would be used; and hence, as a corollary, we arrive at our standard socket.

I am not unaware of the revolutionary character which, in some of its aspects, this movement may appear to assume, nor do I fail to appreciate the practical difficulties which necessarily confront any and every attempt to cope with this standardization question; but, I submit, where the need for amendment is so palpable, and the call for that amendment so imperative, as in this case it is, difficulties must needs be met and overcome. This is not a question for solution by mere process of elimination or survival —in which case it might be left to work its own cure; it is, in my opinion, a matter involving radical change and a new departure.

In view of the fact that high voltage lamps are, in all probability, going to be the rule in the future, the question of a safe socket acquires enhanced importance. Porcelain will, no doubt, come largely into use for this purpose, and this will greatly modify the conditions now governing the lamp base, and will make possible that simplification and economical change in this regard which I have already indicated; and, as even a small saving on the cost of a base becomes a considerable item in the aggregate, it is in this direction, therefore, that economy and improvement should be most encouraged.

In this connection I might mention that the idea lately occurred to me—and I since find that others have put forward the same idea—to engineer this matter economically by means of a *detachable* form of base; a form of base, that is to say, admitting of repeated and continuous use, thus saving expense on renewals. I have come to the conclusion, however, that that idea, though apparently all right in theory, would not operate satisfactorily when reduced to commercial practice; for, even were this re-use made possible by returns on the part of customers—and this is very doubtful—the allowance necessary to induce those returns, added to shipment and other charges, would go far to neutralize any saving there might otherwise be. Regarded from the commercial standpoint, therefore, I come to the conclusion that the most practical and satisfactory solution of the matter is a form of base, or mount, so inexpensive that when the lamp is destroyed the base may be allowed to go with it, as in itself a thing of no value. And it is to this form of base that I allude in the foregoing, and to which I shall later more particularly refer. In practice, all lamps would, in such case, be fitted at the time of their manufacture with this inexpensive mount, and would so be stored, complete and ready for shipment at a moment's notice; the manufacturer, the supplier and the consumer all participating in the advantages that would certainly attend this simplified order of things. The commercial benefit alone that would undoubtedly follow in the train of this standardization of the lamp makes that end worth striving after, for that the present complicated and vexatious state of things operates to retard the progress of electric lighting, and is, therefore, detrimental to its industrial interests, cannot be denied.

But the purpose of these remarks is not, at this moment, the advocacy of any specific form of base or socket; that will follow. Their object, as stated at the outset, is to take the sense of this representative gathering, first, upon the main question at issue—that is, the question as to the desirability of a standard socket—and next, should that question be affirmatively met, to determine, if possible, a line of action that shall best conduce to the desired end.

But, in conclusion, I would urge that any resolution on this question at which this convention may arrive, shall not lose sight of the fact that a standard *base* is the kernel of this matter. Not merely a base chosen as a standard from one of the prevailing types, but a base that is yet to be evolved—one that shall in all respects fulfill standard requirements and so give us as its complement our *standard socket.*

THE PRESIDENT: We will now listen to the paper by Mr. L. H. Rogers on the evolution of the arc lamp.

Mr. Rogers then read the following paper:

THE EVOLUTION OF THE ARC LAMP

For the purpose for which it is intended to be used, the arc lamp, as we commonly know it, is, mechanically and electrically, the poorest designed and constructed piece of mechanism on earth.

The author of such a statement could only conscientiously proclaim it upon such an occasion as this, before a body of men who are thoroughly familiar with arc lamps, and who can instantly spot the first sign of a lack of logic in the argument which must necessarily follow such a radical statement.

Washington was still alive when Volta, a Frenchman, discovered the energy displayed in the consumption of certain metals when immersed in acids. It was simply impossible for him to have realized at that time what the invention or discovery of the primary battery meant.

A few years after this—in 1802—Sir Humphrey Davy connected up a large number of Volta's cells. He connected the positive of one cell with the negative of the next one, the positive of that with the negative of the next, and so on. After connecting about 2,000 cells together thus, in series, he attached a piece of charcoal to the positive of one end of the line, and another piece of the same material to the negative of the last cell in the row. Then, first touching the pieces of charcoal together, and afterwards drawing them slightly apart, the first arc lamp was produced. The pieces of charcoal were in a horizontal position, and as the heated atmosphere between the points caused the flame or mass of illuminated particles to bend upwards in the form of an arch, the name of "arch" light was given to this new form of illuminant. This term has since been changed to "arc."

History gives us no information regarding the importance attached to Davy's new light by his neighbors, his wife, or even his scientific associates. It is more than probable that all of them looked upon him as a cranky old professor, foolishly wasting his time and money. Certain it is that it was utterly out of the question for anyone of that time to imagine that before the close of the century Davy's light would become the commercial light of the world.

In fancy, I lead Davy through the city of Philadelphia, with her streets illuminated by 6,351 arc lamps—the best lighted city on earth—and try to catch some conception of his thoughts as he realizes what his two pieces of charcoal have done for mankind.

It requires 1896 to appreciate 1802.

Some one has said that Faraday was the greatest discovery of Davy's. It must have been that Davy's teachings found good and fruitful soil when instructing his youthful pupil. It was in 1832, three years after the death of Davy, that Michael Faraday discovered the principles of electro-magnetic induction. This was a giant stride in the ultimate development of the arc lamp, for the reason that by the applications of these principles the modern dynamo was born. What Faraday did for the world can better be understood if we can imagine primary batteries of equal capacity and power, in lieu of all the dynamos now used for arc and incandescent lighting. The contemplation is sufficient to cause us to love Michael Faraday.

In place of the large number of troublesome and cumbersome cells, the electric potential or energy necessary to maintain an arc between the two pieces of charcoal was now generated mechanically, rather than chemically; with one piece of machinery, rather than a large number of acid-slopping jars.

No sooner had Faraday announced his discovery than scores of inventors and experimenters began to construct and perfect dynamos. Some great mind like Faraday or Röntgen lets down the bars to the elysian fields, and thousands rush in and stake out all the choice corner lots. These swift-footed inventors, however, are necessary to the evolution of an industry.

Beginning with 1832, one dynamo followed another in rapid succession. Each successive machine embraced some new device or new idea overlooked in its predecessor.

Improvements also began to be made in the device which transformed the electric energy into light. Davy's light, although blinding to the eye, became wearisome, simply as an experiment. It was found that the pieces of charcoal were gradually consumed as they were burned; the one attached to the positive end at about twice the rate of that at the negative end. This led to the necessity of providing some means of feeding the pieces of charcoal toward one another as they wasted away. The pieces of charcoal themselves were improved; they were hardened and baked, and thereafter called carbons.

Thus the arc lamp began its long, rough journey toward perfection. The first efforts were very crude. The electric current passing through the lamp was utilized to cause a screw to revolve slowly. At the end of this screw was attached the positive carbon, which in this manner was fed toward the lower or negative carbon. It is easily seen that the nearer the carbon points approached each other, the less became the resistance and the greater became the flow of the current. Likewise, the greater the distance between the carbon points, the greater the resistance and the less the flow of the current. This ebb and flow of the electric current provided magnetic power of varying strength, which, it was early seen, could be utilized to operate the mechanism to feed the positive carbon. The disadvantage of this, however, soon manifested itself in the fact that as the current was augmented and diminished by the proximity and separation of the carbon points, the current in the line itself was proportionately affected. This made the operation of two or more lamps on the same set of wires impossible, for the reason that the carbons in the different lamps could not be depended upon to feed at the same instant, as well as the effect on the regulation of the dynamo.

The operation of more than one light from one machine was therefore attended with difficulty from the time of Faraday's discovery, in 1832, up to 1875. Some little success was obtained during this period by running a set of wires from the machine to each lamp desired to be operated, though no illuminating to any extent was done in this manner except as a laboratory experiment.

About the year 1875, it occurred to a young electrician, Charles F. Brush, living in Cleveland, that if he could construct a device for an arc lamp which would regulate the feeding of that lamp without affecting the main line, it would then be possible to operate any number of lamps on one circuit, as the current momentarily required to operate the feeding mechanism in any given lamp would leave all the others undisturbed. This was a bold idea, and required inventive genius of a high order to carry it out.

Up to this period, a magnet had been employed in the lamp mechanism, which consisted of a coil of wire wound around a hollow spool, into which was inserted an iron core. When the current was switched on, the action of the coil was to draw the core into the spool. This movement provided means for raising and lowering the upper carbon. Mr. Brush used two spools for added strength. The normal path of the current was around these two spools (in parallel) to the carbon, down through the carbons and then to the negative terminal. He, however, constructed another possible path for the current. Attaching a wire of quite small cross-section to the main wire, he wound it on the same spools, but in an opposite direction to that of the coarser wire. This fine wire, after leaving the spools, passed directly to the negative terminal, making what was termed a "shunt" around the arc. The effect of this unique arrangement was the same as a controller on an engine. The more current passing through the fine wire, the weaker the magnet became, and the all-important point was gained that each and every lamp was a law unto itself, establishing and regulating the arc, and feeding without influencing any other lamp on the circuit.

The device, termed "differential winding" or "feed," was entitled successful, and to Charles F. Brush belongs the credit of first giving to the world commercial arc lighting. He accompanied this invention with one not much less in importance. He invented a cut-out, a device for cutting out any given lamp, provided any trouble should happen to that lamp, so that it could not burn. This cut-out insured the absolute maintenance of the main circuit, no matter what might happen to any single lamp.

Visitors to the World's Fair in 1893 will not soon forget the impressive exhibit made by Krupp, of Germany, the gun-maker of the world. Here, at one side, was shown a piece of iron eight inches thick, and there, by its side, a gun invented for the special purpose of piercing that piece of iron with a projectile. At the next step was seen a thicker or tougher piece of metal with a more powerful gun to pierce it. And thus the race between gun and metal was maintained, until a weapon thirty-five feet long, mounted upon a carriage, which was revolved, lowered and elevated by special machinery, was exhibited, of such power that it could throw a 2,200-pound ball two miles, and, at that distance, pierce the toughest wrought iron plate thirty-six inches thick.

In a somewhat similar manner, a race has been in progress between the device for generating the electric current and the device for transforming said current into light—the dynamo and the lamp. Volta invented a battery and Davy matched it with his lamp—a light formed between two pieces of charcoal. After thirty years, Faraday discovered an entirely new method of producing the electric current; and scores of inventors immediately proceeded to improve the lamp to meet the new conditions. For forty years after this time, improvements in the dynamo and lamp proceeded by easy stages, hand in hand, until the invention of the differential winding which placed the lamp far in advance of the dynamo. Immediately this winding was perfected, then began the rapid improvement of the dynamo to meet, if possible, the new and improved conditions brought about by its use. For the past twenty years and more, this improvement of the dynamo has been in progress, until to-day machines highly efficient, close in regulation, and producing current for 125 2,000-candle power arc lamps, are as common as the poorly constructed, inefficient sixteen-light dynamos were twenty years ago.

These large machines are wonders in their class. It is possible to throw all of the lamps in or out of the circuit at once, break the main line, or, in fact, do anything to break down the machines electrically, and they continue to run, automatically taking care of their load, and without the least hitch of any kind. The efficiency of these machines is, in some cases, as high as ninety per cent. In short, perfection has about been reached in the arc dynamo.

On the other hand, the arc lamp, as it stands to-day, is a poor affair compared to what it might be. It is far behind the arc dynamo as regards electrical and mechanical perfection. What was considered good enough, or even perfect, twenty years ago, will not answer to-day. New uses have arisen for the electric light, and its adoption as an illuminant has exceeded any prophecies ever made for it. The dynamo has again more than outreached the lamp, and the time for a new lamp has arrived.

THE ARC LAMP MUST MEET THE DEMAND

Remember that the title of this paper is The *Evolution* of the Arc Lamp, and that evolution denotes a continuous development. Since Brush perfected the fundamental principles of the commercial arc lamp, what has been done? In 1875, the arc lamp was a great ball of wonderment. In 1878 to 1880, a few were induced to really try them practically. During the next decade, the mad lighting fever was in full sway, and 250,000 arc lamps had been hung up in the United States by 1890. The manufacturing companies were too busy shipping and collecting to think of anything but of something that would burn. The lighting companies were too busy making contracts with municipalities and supplying the demand for light, to ever look to see what was inside the lamp.

But this is the age of close inspection. Municipalities are not paying $350 per year for a 2,000-candle power arc lamp in 1896. They encourage other companies to enter their city limits, and this brings keen and active competition. If competition is not encouraged, or if prices for lighting are not reduced, the "tax-payer"—that tireless individual who never dies—is heard from, and starts the agitation for a municipal plant on the theory of his *new* discovery that electricity costs nothing to "make."

It is not the purpose here to discuss this swing of the pendulum from too high prices—it has, indeed, swung too far already in the other direction—but it does behove us to examine closely into the daily expenses and annoyances to which the electric lighting plant is subjected. There is no business that has developed so rapidly and so radically as that of electric lighting. The frame building, twenty feet square, has been replaced by a handsome brick and iron roofed structure, 150 by 300 feet, and three stories high. The deliberate saw-mill engine, at ninety revolutions, has been replaced, first, by the diminutive, busy, high speed engine at 350 revolutions; then by a larger type of the slow speed engine, and later, by a compound condensing engine at a piston speed of 800 feet per minute. The transmitting devices have been changed from belt to rope, and rope to direct. The boilers have undergone a radical change, and the manufacturer must now guarantee the pounds of water evaporated per pound of coal by his make. Remarkable and needed improvements have been made in the dynamo, as we have mentioned. The efficiency has been raised from fifty to eighty-five or ninety per cent. A 125-light machine is less trouble and care than an old ten-lighter.

In all this development, in this search for high efficiencies, in this attempt to get running expenses down to the minimum, *the arc lamp has been overlooked.* The most important single piece of mechanism in the entire system, it has been the last to receive serious attention.

There are 2,711 central lighting stations in the United States, with $320,000,000 invested. The sole and only object of this outlay is to get *light.* The engines, dynamos, belting, conduits, buildings, are all secondary to the arc lamp. It is the exponent of the entire problem. It is literally in the eye of the public day and night. Its lines of—I was about to say beauty, but who ever heard of a beautiful arc lamp? At any rate, it stands against the morning sky, or the evening sunset, and, in truth, I hear the public say: "It must be the best electricians can do, for I have watched for fifteen years, but have seen no change; they are all alike in their hideousness."

And now let us look at the subject squarely. Let us hold the arc lamp up between the fluorescent screen and the Crookes tube, and in the light of

X-ray, 1896 knowledge, examine the arc lamp hanging in our streets.

We find a device fifty to sixty inches long, made of long tubes or chimneys, a sheet-iron drum, long side rods, and at the bottom a globe holder. We can see Davy's two pieces of charcoal; one is twelve inches long and the other six—the rate of consumption has not changed. We realize that the useful length of this lamp is the vertical length of the carbons. Dividing eighteen inches by fifty inches, we find that the *useful length of this device is only thirty-six per cent of its total length.* The statement may be made by some enthusiastic observer that there are two pairs of carbons, one pair alongside the other; but he must not forget that, with our improved eyesight in 1896, we can look clear through the device, and see, not only the skeleton, but the marrow in the bones.

These carbons are fastened firmly in their respective holders, and the holders are rigid. The burning of the arc causes the carbons to point up quite decidedly. When the current is shut off momentarily, these points fall together, and, it very often happens, slip by each other and wedge. When the current is again sent through the coil, its lifting power is not sufficient to pull the carbons apart; the lamp is rendered utterly useless; the policeman reports it out, and a deduction is made from the bill of the lighting company to the city. To prevent these deductions amounting to more than the original bill, a corps of patrolmen are engaged, whose business it is to watch the lamps all night long, to prevent them going out, as a nurse would watch a sick child.

We find the interior of the devices full of springs; some of them with ratchets and cogwheels; some with six magnets or coils, all with three or more; springs without number, and of every size; regulating devices; auxiliary levers; light and flimsy pieces of every shape and size; the device for gripping the rod in most cases an annular ring gripping the carbon rod by tilting so that its knife edge will hold on the side of rod; the current being conducted to the carbon rod by means of a sliding contact; delicate brushes against which the carbon rod rubs as it feeds the carbons downward; cut-out spools which have little side shows of their own, with independent armatures and additional coils of wire; carbon rods sticking away up into the dark recesses of the chimneys—rods that must be carefully housed and carefully cleaned with crocus cloth each day. We notice also that for three or four inches above the casing the rod cannot be cleaned by the trimmer; it therefore becomes spotted; a bit of weather or a bit of dust changes the nature of the brass, and the current-carrying brush, when it reaches this spot, does not make a good connection; a little blister is formed, which, in turn, blisters the surface of the brush, and this, in turn, blisters the rod the entire length until crocus cloth is powerless to smooth it. The lamp must, in the meantime, come in, for many other little things have happened, and nothing but a thorough overhauling will put it in good condition again.

It would require a volume to recount the details of the troubles that are occurring every hour, in every lighting plant on the face of the globe. You that are within reach of my voice know too well that your arc lamps give you more trouble than all the rest of your apparatus combined. These troubles have come upon you so gradually, however, that you have become accustomed to them. It seems as if some station men actually delight in keeping a force of men reparing old lamps, and a horse and wagon busy hauling them in and taking them out again.

Alexander Dow, electrician for the city of Detroit, connects four 100-light dynamos to one engine, for the reason, as he states, that the ratio of troubles is four to one. I wonder how many dynamos would be connected to each arc lamp, or arc lamps to dynamo, provided the number were dependent on the ratio of troubles?

And now we have reached the year 1896; we have given the arc lamp a twenty-years' tussle, and our troubles are increasing rather than diminishing. The lamp cuts the same kind of figure against the sky that it did in the year 1875. Many details have been added in the interior construction—more magnets and more springs and more cut-outs and more chimneys, and less glycerine—but I do not think the statement can be denied that not one single idea of great merit has been added to the arc lamp between 1875 and 1895.

If this be true, is it not time to consider the question seriously? Are we to give up the question, and acknowledge that the world's best effort for the distribution of light is hanging on our streets through the medium of the arc lamp? Is evolution to be the password to progression in all the arts; in fact, in everything, except the arc lamp?

To return to the opening sentence of this paper: "For the purpose for which it is intended to be used, the arc lamp, as we commonly know it, is, mechanically and electrically, the poorest designed and constructed piece of mechanism on earth."

I am not here to decry the lamp of any manufacturer. It is, however, pertinent to say that any lamp that will allow the carbons to slip by or wedge, under any circumstances, is *mechanically imperfect.* It is an inherent defect in the lamp, and the damages or outages should be charged to the manufacturer of the lamp. What mechanician has determined that the proper way to hold two slim, sharply pointed pencils in a coaxial position, is to fasten them rigidly at their extremities, eighteen inches distant, and then depend on their sharpened points nosing each other correctly? A very much better way would be to leave the carbon holder loose and free, centering by guiding the carbons near the arc. This would make trimming a very easy matter, and admit of cross-eyed men being employed. On second thought, however, we run immediately into difficulties, for, as we cannot change the rate of consumption of the positive carbon, the arc would soon reach one of the guides and burn it away. This would then require a lamp with a stationary arc, and that would require carbons of different diameters, upper and lower; and that would mean a good deal of thinking for the inventor and manufacturer. And so the lamps go out, and the station manager, believing that the arc lamp has been fully evolved, keeps sending his orders to the manufacturer, and the manufacturer will never improve so long as he can fill his orders with old style apparatus.

A sliding contact is a poor arrangement in an arc lamp. It has been tried as thoroughly as any idea ever could be tried. It is the direct cause of the roughness of the rod. The resistance of the contact is too easily increased by the presence of a little dust. The sliding contact in the arc lamp must go.

The carbon rod itself is a troublesome institution.

With an annular ring for a clutch, it must be kept in a uniformly polished condition, or it will give trouble. It is responsible for the unsightly, hideous chimneys, which ought not to be in sight, and yet which cannot be draped. As we are building a new lamp, let us dispense with the carbon rod altogether. We can then cut off the chimneys and shorten up the lamp. Then we can, without much trouble, parallel the carbons with the operating mechanism, and increase the percentage of useful length to total length of at least eighty per cent. With a short lamp, we can make a casing of light cast iron, in such shape as to avoid the necessity of a hood. We can also increase the carbon length, and if we do this, we can choose our own size of carbons; that size for upper that will produce the largest crater, and that size for lower that will best let the light out.

Thus we come back and meet, but overcome, our first difficulty. We construct a focusing lamp, and this leads us to the thought that there is only one correct position for the arc inside the globe, anyway, and that the arc *should* be stationary. If we hang the upper carbon on a chain suspended over a shieve, and attach the lower carbon to the lower end of the chain, we can, with proper adjustment, accomplish many things. As the upper carbon feeds downward as it is being consumed, the chain can be of equal weight—inch for inch therewith. Therefore, when an inch of upper carbon has been consumed, and its weight taken from the cross head, an inch of chain has been added, and the armature remains in the same plane between the pole-pieces of the magnet as before. This is an absolute necessity where the same difference of potential is required throughout the entire range of burning.

Thus we are not restricted by the weight of the carbon, and can use whatever size is most suitable. It having been demonstrated that with eight, nine or ten amperes, a five-eighths inch carbon will produce a larger crater and give more initial light than any other size, it remains only to determine the length necessary for burning fourteen to sixteen hours. This length has been found to be fourteen inches. With an upper carbon of five-eighths by fourteen inches, we find that half-inch by twelve-inch negative plain will burn an equal length of time, leave an equal stub, and keep the arc practically in the same position during the entire run. This small lower carbon will let out the intense light in the crater of the upper; the increase of light at forty-five degrees being something that would astonish most experimenters.

We must not forget that three hundred and twenty millions of money is invested in the central stations alone in the United States, simply to get *light*, and more light with the same expenditure of energy should be a welcome statement to those interested.

By quotations from all leading carbon manufacturing companies of the country, the point is discovered that a pair of five-eighths by fourteen and one-half by twelve carbons is the cheapest possible combination for fourteen to sixteen hours' burning. Anyone can test this point. It is simply the price of one five-eighths by fourteen plain and one one-half by twelve plain carbon against three one-half by twelve plain or seven-sixteenths by twelve copper coated carbons. I have quotations in my pocket that will make a difference of $2.50 per lamp per year, assuming the full number of burning hours nightly, in favor of the five-eighths by fourteen and one-half by twelve carbons.

Again, a five-eighths upper and one-half lower, loose at the joints and guided near the arc, will absolutely prevent wedging or slipping by, whether the lamp be shunt or differential.

I quote from a recent article by Alexander Dow, of Detroit: "In the plant I operate, analysis of the 'outs' for two months showed that lapping was responsible for too much of the total trouble. We were running with seven-sixteenths inch carbons in both holders. We changed to five-eighths inch uppers, retaining the seven-sixteenths inch lowers. Result for four winter months' operation of 1,480 street arcs, is just one 'out' by lapping."

Mr. Dow is ahead of the lamp he tried to fix. He neglected to state that he was compelled to break his five-eighths inch carbons off so that the weight would be no more than a seven-sixteenths by twelve. This lamp was not designed on evoluted ideas. A heavier weight in the upper carbon holder would position the armature in a different plane as regards the operating magnet.

The double carbon lamp has outlived its usefulness. It filled a gap for a few years. Its only recommendation is that it will burn all night long. Its drawbacks are numerous. More mechanism is required: two carbon rods with two sliding contacts. The arc is struck well up near the top of the globe at one side—not in the center—and travels downward. This causes an uneven heating of the glass, which results in globe breakage, especially in severe climates. I have known a number of superintendents who always took the precaution to crack their globes with a soldering iron before putting on; then, by putting on a net, the unequal expansion and contraction was overcome.

Never losing sight of the fact that the function of an arc lamp is to *diffuse light, as much light as possible, and in every direction possible;* any unnecessary opaque substance that interposes between the arc and the surrounding space to be illuminated shows a defect that is simply monstrous. With one pair of carbons burning sixteen hours, we need have only one single arm of small cross section reaching down to sustain the globe holder. The shadow from this arm can be thrown directly against the pole or building, leaving absolutely unobstructed light for the street. We can arrange the trimming to be done quickly and without touching the globe. The globe can be cleaned without removing.

It is a very noticeable fact that those who have had the most intimate acquaintance with arc lamps, and have operated practically the largest lighting stations for the longest time, are the men who are the most eager to hear of a lamp constructed on new principles.

The West Side Park, Chicago, is about purchasing a large arc-lighting plant, one of the largest ever installed at one time. They want 750 arc lamps. The specifications drawn by their engineer, Mr. Forée Bain, reached me a few days since. They are sufficiently unique to be preserved. His idea, I think, is new. He asks a number of questions. The bidder is to answer these questions on blanks furnished; said answers to form the guarantees of the bidders.

These specifications read as follows:

Single or double carbon?
Size of carbons? Upper Lower
Cross section?

Market price of such carbons per 1,000?

Length of time the lamp will burn with one trimming, in circuit of 9.6 to 10 amperes and a difference of potential of 45 to 50 volts at terminals of lamps?

With 6½ amperes and 45 volts?

Will the lamp burn at a practically constant voltage of 45 to 50 volts while the current may be changed from 9.6 amperes to 6½ amperes?

If not, what range do you guarantee?

In stating guarantees above, do you refer to the use of plain or plated carbons?

State make of carbons referred to.

If such carbons are covered by patents making them a monopoly, state price per 1,000 you hereby guarantee they will not exceed for a period of five years from date hereof.

By what means are the carbons adjusted to a coaxial position?

By what means are they maintained in a position coaxial with regard to each other?

What is the extreme length of lamp?

What is the weight of lamp with globe, trimmed and hung ready for operation, with hood and hanger board, if such be necessary?

How many side rods for supporting the globes and negative carbons?

Diameter of each intercepting the rays from the arc? Length?

Is it necessary to remove or disturb the globe when trimming the lamp?

Does your lamp require a special globe?

If so, at what price do you guarantee they will not exceed for a term of five years from date?

Of what material is the jacket or case composed?

How removed for inspecting the operating mechanism?

Is the lamp shunt or differential?

After the arc is struck, is the series coil retained in circuit?

Is its responsive mechanism in continuous active motion?

What is the electrical resistance of the series coil and its connections?

What is the resistance of the shunt coil?

Of what size wire is it composed in decimals of an inch?

How many active pivotal joints in operative mechanism?

How many springs in the lamp?

How many variable adjusting devices are there in the lamp?

Are they sliding or pressure?

Of what metal composed?

Maximum current carried?

Can they be readily replaced?

Will the automatic cut-out re-establish the arc when the carbons come together?

Within the limit of what number of volts can the cut-out be adjusted to positively operate?

If a double lamp, what is the difference of voltage between two pairs of carbons when in normal operation?

Is any resistance cut into the main circuit when the lamp automatically cuts out?

How many ohms?

What is the form of cross section of the carbon feeding rod?

How is the circuit completed through the rod?

What is the area of surface contact of the clutch with the rod in decimal of square inch?

What is the voltage and current at which the lamp is best adapted to operate?

State the maximum and minimum voltage between which the lamp will operate and feed in practical service, during a period of six months.

Mention any special features of your lamp.

The man who could ask those questions is hunting for an arc lamp different from the ordinary. They show that he has fought and bled with a multiplicity of spools, springs, rods, sliding contacts, lapping carbons, broken globes, and rusty sheet-iron cases, and that he has lived within the dark shadows thrown by the old style lamps, and gazed for years upon landscapes marred by the contours of the arc lamps of the period of 1875 to 1895.

MR. ARMSTRONG: Some modest men behind me say that this is the cheeriest, prettiest and most interesting paper they ever heard at one of these conventions. I think we ought to do a little more than just move a vote of thanks to the author of this paper. We cannot say any more than that; but in making that motion I want it to be distinctly understood, speaking for myself and these modest men in the rear, that I feel that the good suggested, which may come from this paper, is something that merits the heartiest thanks, not only of the electric light men, but of the never-dying, ever-present, ever-active individual referred to in the paper—the tax-payer.

The motion of thanks was carried.

THE PRESIDENT: We will now listen to some remarks from Captain Brophy on electrolysis.

CAPTAIN BROPHY: Mr. President, as you well know, I have not prepared a paper; but this subject has been on my mind for a long time, and I cannot easily get rid of it, so it is not necessary to place much of it on record.

With the advent of the arc light came the same line of construction that had been adopted by the telephone and telegraph companies. The first few lines that were put up were composed of bare wire, carried on the same style of insulator pole and fixture as the telephone and telegraph wires. This was soon dispensed with, and an attempt was made to insulate the wire. That attempt has not, I regret to say, been very much improved upon to this day. The insulation used, as a rule, for overhead wires is called so by courtesy; but an attempt to cover these wires, exposed to the atmosphere, by a costly insulation, would be folly, as there is nothing that would withstand the changes of atmosphere and temperature.

For some years previous to the attempt at placing electric light wires under ground, the telegraph companies had successfully operated their lines, to some extent, both under ground and under water. The so-called early types of insulation for electric light circuits consisted of a cotton braid—one or more coats of braid placed on the wire—and this braid treated with a covering of paint whose only virtue was that it rendered the covering non-inflammable. As an insulator, when wet, it was an absolute failure; when dry, it passed off very well. I believe the underwriters were responsible for this grade of insulation; they thought that the only provision they had to make to prevent conflagrations from the electric current was to have something on the wire that was non-inflammable. It was rightly christened Underwriters' wire. Some irreverent fellow has since then called it "Undertakers' wire."

The first attempt to place wires under ground, other than the telegraph wires, was made in Chicago by Professor Barrett, the city electrician, who was obliged, owing to the remonstrances of the residents in a certain neighborhood, to place some of his fire-alarm wires under ground. This he did in a crude way. From that day he had the underground bee in his bonnet. He has, however, done some good work in that direction since that time. He placed many of his fire-alarm wires under ground. They operated successfully for a number of years, and are operating successfully to-day. These earlier types had no lead covering. Later on, the city of Chicago and Professor Barrett determined that all wires should go under ground, and that electric light wires, among the rest, should be buried. Chicago, or, rather, the people in the electric lighting business in Chicago, paid dearly for the series of experiments that were tried in that city. Other people throughout the country profited by it. I will not enumerate the vexations and expenses that were incurred in that windy city.

The earlier wires were laid in wooden pipes, wooden troughs, pump logs, and various kinds of tubes; and I think there can be found in that city to-day almost any kind of duct and insulation. In the city of New York, Mr. Edison laid a complete system of underground conductors. This system has proved fairly successful. The present types of ducts are numerous, but the one most extensively put down is cement-lined sheet-iron pipe, laid in a bed of concrete, through which the cables, either lead-covered or plain, are drawn. Manholes are placed at different points for convenience in drawing these cables through the ducts, connections being made therein to each separate length.

The problem of laying wires under ground and operating them successfully was not an easy one, and, I must confess, is not yet completely solved. It was quite different from placing telegraph and telephone wires under ground and operating them successfully. In the first place, there was very little demand for that kind of conductor, and very little incentive for the manufacturer to produce it. As a result, nearly all the early attempts at placing them there and operating them were failures. However, as the individual referred to in the last paper (the tax-payer), and others, kept prodding the electric light people, one city after another has seen fit to compel the wires to go under ground; notably, the city of New York. You are all familiar with the history of that attempt. You are also familar with the autocratic powers placed in the hands of the Board of Electrical Control. The companies here know how heavily that weighs them down, and how cheerfully they would have that load taken from their shoulders.

The reasons for going under ground are numerous. First comes the public demand. The public know little or nothing of the difficulties or of the cost of placing the wires under ground; but they insist on their going there, as they insist on getting light for nothing. Next, the politician, the man who is elected mayor, and has his head brimful of new ideas. He either seeks to place all the wires under ground, or to build a municipal lighting plant, and through that means stop the "robbery of the tax-payers" by the local electric light company, as it appears to him. Then, the legislator, who, when he first visits the State house and feels the weight of responsibility and the eyes of his constituents upon him, thinks himself in duty bound to introduce some kind of a bill, no matter whether it passes or not, or whether it is good, bad or indifferent. It gets his name in the papers, and assures his constituents that he is doing something to earn his money. Then, there is the competitor, sometimes nursed—and too often so—by the manufacturing companies, who, for the sake of selling their goods, throw commercial honor to the winds and sell it to any fellow who can give his note for it and set up a dynamo, a few poles and a few lamps, and either sell out to the older company or make its life miserable by wiping out every vestige of profit that was ever in sight.

Then, there is the other factor—the one of self-protection against these pirates. There are some companies that have already, without being asked to do so, requested the privilege of placing their wires and ducts under ground. It is my opinion that this is, in many cases, a wise step. After the companies have gone to that expense and secured the right of way through the streets, these little pirates are generally kept out.

The next thing is to prevent the establishment of that popular fad, now known as a municipal lighting plant, which is another name for a nursery where little statesmen for a cent can be spawned readily—where the ward heeler finds an easy job and a safe resting place until there is a change in the administration. The cost of producing light in such plants can never be ascertained. If it costs too much, it is charged to some other department. Some time or other it may leak out, but I do not think that I shall live long enough to see it. As a matter of simple justice, I must say that not all these plants are carried on on these lines; but so few of them are not that they are hardly worth mentioning.

Having now been compelled, as we will assume, to go under ground, what are the difficulties to be met with? After placing your wires under ground, if there are no stray currents to disturb them, you are reasonably safe for a number of years; for the manufacture of insulated cables for underground work has now been brought to a very high state of perfection, and you can get almost any required degree of insulation. But, unfortunately, in this country, where we want everything of the most approved type, and where, in order to get it, we will run almost any risk, we have, co-existing with the electric light, the single trolley electric railway system, which has done wonders in building up cities and towns, and in bringing people of small means within the reach of comfortable homes where they can get a reasonable amount of fresh air and God's sunlight. The horse, as a motive power for propelling street cars, is fast disappearing. It is a pity that the rail of the electric street railway was adopted as a part of the circuit, and those who introduced it little knew what the consequences would be. The first to feel the effects of this was the Bell Telephone Company. They fought vigorously for their prior right to the earth. (Laughter.) In passing, I may say that they have maintained their right to almost all of it; but the courts decided that they were not entitled to the whole of it, consequently, the street railways have taken quite a large slice. This compelled the telephone company to abandon the earth as a part of their circuit, and to increase, by one hundred per cent, the amount of wire in the air. This increase was so great in many cities that it threatened to become difficult to see the sun if it continued, and the birds could not fly down and sing for us. With wise forethought, they have solicited and obtained in most large cities the right to lay their wires under ground, most of them being laid in lead-covered cables.

For special reasons, it is found necessary to produce a cable of very low static capacity for telephone purposes. The best—the one now generally adopted—is that with an insulation of dry paper, which gives a high degree of insulation, and, at the same time, a low static capacity. These desirable results are obtained by this style of insulation, but it depends wholly on the continuity and perfection of the lead for its life. Dampness passing through the lead, by reason of injury, mechanical or otherwise, of course destroys the insulation of all the wires within the cable. After the telephone company fought for the earth, not being able to hold the whole of it, as I have already stated, they took a portion of it in which to lay these cables. They found their arch enemy after them again—the electric railway. Owing to imperfect bonding, or to the lack of conductivity of one side of the circuit, these large currents sought and found the earth; in other words, the potential of the earth was raised at places distant from the station, and was lowered again within a radius of a half or a quarter of a mile, more or less, depending largely on the state of the soil on which the station was built. The earth's potential there became lower than the cables; these lead covered cables affording a much easier path to the negative side of the dynamos than some portions of the earth. Large volumes of current were conveyed through them. No difficulty occurs at the point where the current seeks the cable, but at the point where it seeks to leave the cable—where the earth's potential is lower—here the trouble begins.

Electrolysis. What is it? Can it be prevented, and how? Electrolysis proceeds on the same line, and under somewhat similar conditions, as the well-known method of electro-plating; the moist earth being an immense electro-plating bath of various resistances, while the lead covering of the cable, metal gas and water pipes, are the negative and positive poles. Corrosion of the metals, due to the electrolytic current, goes on as surely as fate. There is a difference, and perhaps a wide one, between the working effects of an electro-plating bath and the destructive corrosion of iron and lead pipes and lead-covered cables. All currents of electricity flowing into the earth seek the best conducting medium, and cause the destruction of the latter at the point where they seek the earth again.

The corrosion of metals is due to the following conditions: A thin film of water surrounds these metals, and it is decomposed into oxygen or hydrogen by the electric current. Oxygen, when freely released, is always intensely active in combining with any metal present. The lead covering of the electric conductor within the ducts, or buried in the earth, is, as a rule, covered with a thin film of water, and it is not infrequently the case that the ducts and manholes are filled with water. In every case, the lead takes the place of the positive and negative plates in the electro-plating bath. If the current of electricity, after traveling along the surface of lead, leaves it to seek a point where the earth's potential is lower than that of the lead, it decomposes the water, and the free, nascent oxygen immediately enters into combination with the lead surface to produce lead oxide in the form of a paste, and iron oxide or rust in iron. The crust of oxide being permeable by water, a fresh surface of the metal is in contact and presented to the moisture; and the process is continued indefinitely until the lead covering is destroyed. The amount of metal thus decomposed depends on the amount of current flowing from the metal to the ground, while the potential may be as low as one-tenth of a volt. From a group of telephone cables running by the Albany street power house of the West End Street Railway Company, in Boston, has been taken 500 amperes, which would decompose about 2.5 pounds of the metal in twenty-four hours. To lay pipes or electric light cables under ground under these conditions, and expect them to possess any lasting qualities, would be the height of folly.

What is the remedy? The only real remedy is to cease using the rail as a part of the circuit, and use a metallic circuit. But to bring about this condition of affairs is a task not easy of accomplishment. The courts have already decided that the electric railways have a perfect right to use the earth if they see fit. The only remedy, then, will be, if the water systems of cities and towns become endangered, for the people of those municipalities to seek redress; and they can possibly obtain it. Now that we have the electric railway with us—and we would not part with it under any circumstances—let us do what we can under these present conditions to reduce this evil. Public opinion has now arrived at the point where it will demand the burial of wires in congested districts. I apprehend that in all our large cities in Massachusetts the initiative will immediately be taken to have this done; the companies either doing it themselves, voluntarily, or being compelled by law to do so. Boston is obliged by act of the legislature to do it. It seems a little unjust that after the state legislature or city council compels a company, for reasons of public safety, to place its wires beneath the ground, the property should not be protected after being placed there; still, I see no easy way of doing that at the present [illegible]. Under certain conditions, this evil can be very [illegible] reduced. Boston is very favorably situated in that [illegible]pect; the power houses are at the extreme [illegible]ir congested districts. By connecting the [illegible]de of the dynamo to the trolley, we have [illegible] what is known as the danger district within a [illegible] of less than half a mile from the station. [illegible]method that has been adopted there is to provide [illegible] easier path than the earth to the negative side of the dynamos for the current flowing over the cables; in other words, to run out very large return feeders for the sole purpose of taking this current from the lead covering, and thus, in a measure, but not wholly, avoiding this corrosion on their surfaces. The stations, too, are situated on low, marshy ground, and for that reason we are enabled to accomplish this with very little outlay of copper. If, on the contrary, a power station is built on a rocky foundation, and that extends to any distance from the station, it will be necessary to extend these return cables beyond the rock formation. In any portion of a town or city where the potential of the earth is higher than the cable, no trouble will exist; but where the earth's potential is lower than the cable, the trouble begins. If all cities were like Boston and Worcester, it would be an easy matter to remedy this evil in a measure; but it can never be wholly remedied or removed in this way. The earth's potential is very low indeed in some places, and it would be difficult, perhaps, to cause all the current to flow to the negative side of the dynamos over another path.

The cost of this remedy depends largely, as I intimated before, upon the conditions of soil surrounding the power stations. No doubt there are places where the cost would be so great that it would be useless to attempt it, and it would be better to use the metallic return at once, instead of the rail and ground. In Boston we have reduced it very much. I found by making tests the day before I came away that, even with all the precautions that have been taken (and in justice to the West End Street Railway Company, let me say that they have done everything they know how to do to prevent this trouble, freely and without hesitation), we are not really able to say to-day that all our cables in the vicinity of the power house are safe from corrosion due to electrolysis.

I have sometimes thought, and still think, that in some cities, particularly where coal is cheap—cheaper than copper, even cheaper than rail bonds—it will be impossible to use lead-covered cables in certain portions of such cities; and it seems to me that the manufacturers of cables will have to bestir themselves to find something for a better protection to the insulation of the wires placed under ground than lead or other metals, unless the electric railways adopt an entirely different mode of construction. The perfect bonding of rails has proved a problem that is yet unsolved.

While a bond may be perfect to-day, six months hence it may offer so much resistance as to render it almost useless by the electrolytic action in the moist earth between the two metals, copper and iron; so that I place no confidence in many rail bonds now in use. There have been many suggestions and plans made for overcoming this difference in the potential of the earth by means other than that I have described; but they are expensive, and very few of them have been put in operation.

In conclusion, I must say that if you are obliged to go under ground, and obliged to use lead-covered cables, in justice to those engaged in the electric lighting business, the authorities that oblige you to do so should protect your property after they have compelled you to place it there. (Applause.)

ANNOUNCEMENTS.

New York, May 7th, 1896.

"C. H. Wilmerding, Esq.,

"President National Electric Light Association.

"Dear Sir: The United Electric Light and Power Company desires to extend to all delegates and their friends a cordial invitation to visit the new central station which this company has recently constructed at the foot of East Twenty-eighth street, New York.

"This station is designed for 20,000 horse-power, with a coal storage capacity of 6,000 tons. Five-thousand horse-power is now installed and in operation. The main engines and dynamos are in 1,200-horse-power units, and the boilers in 600-horse-power units, and all machinery in the station is direct connected. The two-phase, three-wire system is employed, and motors, as well as both arc and incandescent lamps, are operated from the same machines with entirely satisfactory results. One special feature of the station is the concentration of a large amount of power on a very limited space. All boilers, engines, dynamos, pumps, etc., are on one floor, and are carried on foundations resting on solid rock, yet the ground space occupied per indicated horse-power is practically the same as that required by a consolidated locomotive, of the latest and most powerful type, in the round house.

"The station will be open for inspection at all times, both day and night, and no form of pass will be required other than the convention badge.

"Very respectfully,

"H. W. YORK,

"Chief Engineer."

It was also announced that a photographer was waiting to photograph the gentlemen in attendance at the meeting, and that upon the adjournment of the meeting the picture would be taken in the large hall on the seventh floor.

The meeting then adjourned until 2.30 o'clock.

SIXTH SESSION

The president called the meeting to order at 3.10 o'clock.

THE PRESIDENT: The first order of business is the paper by Mr. Albert A. Cary on steam boilers, their equipment and management.

Before Mr. Cary begins, I should like to state that, owing to the lateness of the hour, we shall have to limit the discussion on the paper and promptly at four o'clock go into executive session.

Mr. Cary then read his paper as follows:

STEAM BOILERS, THEIR EQUIPMENT AND MANAGEMENT

BY ALBERT A. CARY

One of the first considerations to be taken up in designing a new boiler plant is found in the question, "What style of boiler is best adapted to our work?" And, after this is answered, the other question following closely at its heels is, "Are our available funds sufficient to equip this plant with the chosen form of boiler?" Unfortunately, we find a by no means small percentage of prospective steam users asking these questions in the reverse order, and it is largely due to this fact that we find so many tank-makers in the boiler business; so many coal companies flourishing and growing rich at the steam-users' expense; so many boiler insurance companies springing up in every section of the country, to say nothing of the profits of the owner of the boiler, which unnecessarily go to keeping the boiler plant in repair and the coal pile replenished. All these troubles do not result from the doings of the "penny wise, pound foolish" man, but there is also a large percentage of plants erected where ignorance has been the partner of the designer, and we find the outsiders again reaping the profits that properly belong to the victim. After many years of close contact with steam-users, I have been led to believe that there is no branch of engineering in which more money is foolishly spent, due to the ignorance of the purchasers, than in steam plants, especially those of small size, say from 300 horse-power down.

I have met many manufacturers that are bright, practical, mechanical men, understanding their business in all its details to a degree that commands your admiration, but when it comes to their steam plant, alas, how little they know, although they think they have mastered this "easy subject" away back in their early days, and there is nothing left for them to bother themselves with, and nine times out of ten you will hear them boast that their steam plant is a model one in every respect. In these very plants you will often find smoky chimneys painting the whole neighborhood with foulness, and not a single attempt made to stop this; you will find many of these boilers filling up with scale, and this is calmly accepted as a necessary evil; you will find miserable firemen wasting coal; and so I might continue this list of unnecessary evils to a considerable length.

In many of this class of plants no effort is made to determine the actual amount of power used, unless by a very popular process called guessing, and this extremely delicate operation is often left to the man who opens the throttle or shovels the coal under the boiler. He, naturally wishing to show up in the best possible light, often decides upon a pretty high figure, which I have on more than one occasion been forced to lower by a large percentage after conducting a careful test. This man, after finally deciding upon the amount of power he thinks the plant is taking, carries these figures to "the boss." Then follows a lot of profound figuring, and it is finally shown that the steam plant is *wonderfully* efficient, and the boiler is often found to be evaporating something like sixteen pounds of water to a pound of coal, and all the owners and attendants of the plants in the neighborhood are made envious over these wonderful results.

From such false results as these, the excessive amount of coal used in these plants is considered a remarkably low consumption for the "very large amount of power developed," as has been determined by the guessing process. The owner settles back, perfectly contented with his steam plant, and then all progress and improvements stop. His self-satisfied ignorance and boasting finally induce his neighbor (who knows just as much about steam plants as he does) to put a similar plant in some new mill he is building, and so the installation of inferior steam plants continues and becomes almost epidemic.

There is no one that enjoys and profits more by this state of affairs than the coal-dealer. He stocks up with all kinds of coal, good, bad and indifferent. He furnishes the class of steam-users we have described with anything and everything in the coal line, and gets good prices for what he is selling. But this is not the condition of affairs in up-to-date plants, designed and managed by competent engineers. The coal-dealer knows that in these plants the amount of coal used and water evaporated is continuously kept account of, and as an inferior coal will evaporate less water than the good, pound for pound, he knows that a delivery of inferior coal will be detected at once, and that it will cost him a customer if he is not very careful.

Now, to return to the equipment of our new boiler plant, and consider the matter of selecting the boiler best adapted to our use. This is a somewhat weighty question, and unless we are thoroughly posted in the practice of to-day, we had much better hire a competent engineer to make this decision for us, and the money paid to him will, in the end, be found to be an excellent investment.

There is probably no branch of trade employing abler men to discuss the merits of their output and sell their product than are found in the boiler business, and I am really forced to pity the inexperienced purchaser that is not perfectly capable of forming his own individual opinion of the relative merits of the various boilers offered to him and their adaptation to his use. Such a man is very apt to be influenced by the words of the smoothest talker, or the one who tells him his "story" last, and in the end he is pretty sure to make the serious mistake of selecting a boiler very poorly adapted to the service it is intended for, or one far inferior to the boiler he started out to buy.

I am sure that those present that have passed through this ordeal will bear me out in these statements, and this merely emphasizes what I have said before; that is, that if you are not thoroughly competent to select one of the many boilers, hire a good, able mechanical engineer, one experienced in boiler practice, and let him decide for you. I do not mean by this that you want a man that knows simply one make of boiler, and uses it for every plant for which he is retained. There are too many men of this kind, unfortunately, and by the narrowness of their decision they prove that they are incapable of judging the respective merits of the various steam boilers offered to them. Such men are apt to make you pay exorbitant prices, or else they are apt to give you something you do not really want, and they prove in this way that they are not worth their hire. In selecting the best type of boilers for a certain specific use, the conditions under which it is to be run must, of course, be considered. To cite a few examples: Let us first take up the case of a boiler to be used in a rolling mill, where we find a long line of connected rolls running across the middle of the mill, with a large reversing engine connected at one end, in most cases by gearing. This engine, we generally find, has a cylinder of large diameter, and a comparatively short stroke. We find lacking some of those refinements in valve gear that promote economy in the engines used for other purposes, and, in consequence, we find these engines calling for from fifty pounds of steam upward for each horsepower developed. These engines are frequently started up with the full load on, taking steam about the entire length of their stroke, and making the severest kind of demand on the boiler for the supply of steam required to furnish this large amount in a very short space of time. In such a case as this, the boiler must be of such design that it will deliver a very large quantity of steam in a very short space of time, and this may be accomplished in several ways, viz.: First, by having a boiler with an abnormally large steam space; second, by having a boiler with a large water capacity, and a moderate sized steam capacity; third, by having large, hot-water storage cylinders to supplement the quantity of water held in the boiler; fourth, by running the boiler at a steam pressure several times higher than that used at the engine, and delivering the steam through a very large reducing valve, which reduces and delivers the steam from the high pressure to the pressure required at the engine.

Each one of these methods has it own advantages and disadvantages, and the first one is probably the worst arrangement that could be made; in fact, it may be regarded as impracticable. An extremely large steam space is neither desirable nor necessary; it increases the size of the boiler unduly, as well as increasing the heat radiating surface. Our second method of caring for the very sudden demand for steam is by providing a large water capacity. Under these conditions, a fall in pressure is depended upon to supply the steam required until the boiler is able to supply the demand continuously. With such an equipment, when the throttle is suddenly opened, admitting steam to the engine, the steam from the steam space of the boiler first rushes into the cylinder, and we will say, for example, that the boiler pressure drops from one hundred to eighty pounds. Let us next assume that we are drawing our steam from a plant of boilers holding 100,000 pounds of water. The temperature of the water under eighty pounds pressure is, we know, 323.9 degrees Fahrenheit, while its temperature under one hundred pounds pressure is 337.8 degrees Fahrenheit. By turning to our steam tables, we find the total heat in one pound of water under the above conditions as follows:

One pound of water under one hundred pounds of steam pressure contains 308.7 heat units.

One pound of water under eighty pounds of steam pressure contains 294.0 heat units.

Thus when the pressure drops from one hundred pounds to eighty pounds, the total heat required in each pound of water is less by 14.7 heat units. Multiplying this by 100,000, we have 1,470,000 heat units available for the generation of steam. Divide this by 886.7 (the number of heat units necessary to evaporate one pound of water at 323.9 degrees Fahrenheit into steam), and we find that we have 1,658 pounds of water evaporated during the time of the reduction of the pressure from one hundred pounds to eighty pounds. Now, if our engine uses 500 horse-power, and sixty pounds of steam is required per hour per horse-power (equal to one pound of steam per minute per horse-power, or 500 pounds of steam per minute for 500 horse-power), we divide 500 into 1,658; we see that from this lowering of temperature or pressure we liberate sufficient heat to supply our engine with steam for about three and one-third minutes, even though all other sources of heat are withdrawn, but this is not the case; the fire in the furnace will add its heat constantly at the same time, and thus we soon find an equilibrium established, and the boilers will finally be able to supply the engines steadily with the steam required.

Let us see how much of a boiler equipment we should need to cover the conditions we have just outlined. Let us suppose that we take horizontal tubular boilers sixty-six inches diameter and eighteen feet long, containing forty-six four-inch tubes. One boiler of this kind (allowing one-third of the diameter vertically to measure the steam space) will hold about 14,000 pounds of water. Dividing this into the 100,000 pounds of water, we shall find that it will require seven boilers, which, if rated by the regular builders' rating, would be sold as 668 horse-power. This is about one-third in excess of the rated engine horse-power, but, considering the excessive duty called for in such service, it can be considered as a well balanced plant.

The third method of providing for a great and very sudden demand for a large quantity of steam is accomplished, as has been stated, by providing one or more large hot-water storage tanks, which are used in connection with one or more regular boilers. The principle of working in this case being the accumulating of large quantities of heat in the water held in these tanks under pressue to be called upon when needed for steam making purposes; a principle very similar to the storing of electricity in storage batteries, to be drawn upon at any instant when the current is needed. This is known as Halpin's system of thermal storage, and in the case under consideration its operation is almost identical with the second method just described; that is, it depends upon a fall in the steam pressure when the body of water gives up some of its heat, which results in the formation of steam at a lower pressure. In this system, of course, a fewer number of boilers are used, but the quantity of water handled by these boilers is proportionally greater.

The arrangement of these thermal storage tanks in connection with the boilers is comparatively simple. The tanks are simply plain, cylindrical boilers, but, of course, they must be capable of sustaining a pressure fully equal to, and generally much greater than, the working boiler. The working boiler is run full of water, and is made to deliver a constant stream of hot water into the storage tanks, independently of the rate at which the steam is drawn from them; and for the best results this system should be run at at least one hundred pounds pressure in excess of the pressure required at the engine.

We now come to the fourth method for supplying our sudden demand for steam, which was originated by the author. This is probably the most economical manner of solving this problem; first, as regards the original cost of the equipment, and, secondly, as regards cost of operation. By this system, the number of boilers required is reduced; the quantity of water needed is much less, and this consequently lessens the amount of fuel required, and the consumption of steam at the engine is also reduced. Of course, we shall need, for this system, boilers that can be safely operated under high pressures; and let us here (for the sake of comparison with the example we have given under our second system) suppose that we have in our new plant two water-tube boilers, each having a rating of 250 horse-power and running under 300 pounds pressure, supplying steam to our 500-horse-power rolling-mill reversing engine, which is designed to work with eighty pounds pressure.

In the first place, we shall be obliged to place reducing valves in our steam main, between the boiler and engine. This will probably require more than one valve, as there is too great a range in pressure between 300 pounds and eighty pounds to be successfully handled by a single valve. The object of these reducing valves is to receive the steam from the boiler at a pressure higher than that required at the engine, and, by means of throttling, reduce this higher pressure to the eighty pounds required. The fall in pressure at the boiler side of the valves may run all the way from the 300 pounds almost down to eighty pounds, but the pressure on the reduced side of the valves will always remain a constant eighty pounds. Steam at any higher pressure than eighty pounds will only cause a waste of steam at the engine, on account of the high terminal pressure at the end of the stroke. This, of course, refers to our reversing engine, while with an automatic cut-off engine too high an initial pressure will cause, towards the end of the stroke, the wasteful negative pressure which, on the indicator diagram, will be shown by the terminal loop. Returning to our rolling-mill engine, which is exhausted to the atmosphere, the terminal pressure, of course, increases as the initial pressure is increased about eighty pounds. Thus it will be seen that reducing valves are a source of great economy in such practice. These reducing valves must be very *large*—larger than required in ordinary practice.

As for the difference in expense in running boilers at a pressure of 300 pounds instead of one hundred pounds, it is hardly worth consideration. Practically speaking, a pound of coal will evaporate the same number of pounds of water into steam at any pressure. To show the truth of this statement, let us take a pound of steam at one hundred pounds pressure, and, again, the same weight at 300 pounds pressure. The total heat in the first is 1,185 heat units, while in the latter the total heat is but 1,209.3 heat units, a difference of only 24.3 heat units; and when we consider that our coal delivers between 13,000 and 15,000 heat units when burned, from sixty to seventy-five per cent of which are utilized by the boiler in making steam, no difficulty can be had in comprehending our statement, that practically the same amount of water can be evaporated per pound of coal, irrespective of the pressure. Now, in order to investigate the working possibilities of this arrangement, let us consider our plant somewhat in detail. Taking a well-known horizontal water-tube boiler rated at 250 horse-power, we find that, under ordinary working conditions, it contains about 20,000 pounds of water. Two of these, making a battery of 500 horse-power, will therefore contain 40,000 pounds of water. As has already been stated, our 500-horse-power rolling-mill engine is designed to be operated with eighty pounds pressure. The steam space and steam-liberating surface in these boilers are designed to be of sufficient size and capacity to secure dry steam when the boilers are supplying the maximum demand. It must be remembered that all sudden lowering in the pressure of boilers is followed by an increased ebullition of the water, which has a tendency to project particles of water into the steam space; and if ample space is not provided to allow most of these particles time to drop back again into the water from which they have risen before the out-rushing steam carries them away into the steam pipes. trouble is very apt to follow if this moisture is not entrapped or separated from the steam before it reaches the engine. The exact steam-liberating surface required in a boiler is pretty difficult to define, as experiments in this direction have not determined this with any precision; but it is safe to say that when steam is taken from the surface of water at a speed greater than three feet per second, water is generally carried with it. A curious fact has been noted in this matter, which is that after steam once begins to pick up water as it leaves its surface in a boiler, it will continue to do so for a considerable time, even though the speed of its exit is considerably less than the speed at which it first began to pick up the water. The advantages of reduced steam space have already been discussed under our first system, on page 351. Next, let us consider the amount of water required here and compare it with the second system. Here we have 40,000 pounds in our boiler, while there we had 100,000 pounds.

One pound of water under 300 pounds steam pressure contains 391.9 heat units.

One pound of water under eighty pounds steam pressure contains 294 heat units.

The difference is 97.9 heat units.

We thus find that a drop in pressure in our boiler from 300 to eighty pounds will render available, from each pound of water contained in the boiler, 97.9 heat units; therefore, with 40,000 pounds of water, we shall have available 3,916,000 heat units to generate quickly the steam required. Dividing this by 886.7 (the number of heat units necessary to evaporate one pound of water into steam from the temperature of water under eighty pounds steam pressure), we find that we shall have generated 4,416 pounds of steam through this fall in pressure, and, as our engine requires 500 pounds of steam per minute, we find, by dividing, that we have a supply of steam which will supply our engine for 8.83 minutes, to say nothing of the steam generated directly by the fire during this interval. Thus you will plainly see that we have almost three times as much reserve energy available as in the second system, while we have but two-fifths the amount of water. It is a well-known fact that water-tube boilers are very rapid steam-makers, and, in consequence of this, after dropping their pressure, as has just been stated, they will commence "picking up" immediately, and the nine minutes during which they are delivering steam from the available heat they have stored in the water under 300 pounds pressure, is more than ample time for them to recover their maximum pressure, and thus the desired result is accomplished.

To show where economy in operation occurs in this system, there are many points that may be considered. In the first place, there is a lesser numb of boilers needed, requiring a smaller boiler house and thus economizing room. Fewer boilers require fewer attendants. There is but forty per cent of the water needed in this system that is necessary in the second one, and that means that it will require but forty per cent of the fuel, when starting the boiler, to raise the water from the temperature of the feed to the temperature of the steam; and it must be remembered that the amount of iron work and masonry to be heated and maintained at a working temperature is far less in this system than in any other. We have now reviewed what might be called one extreme of boiler practice, and have considered the various methods of caring for extreme and sudden demands for steam in large quantities, and, in contrast to this practice, we might now pause a moment to find a boiler working under the other extreme condition; that is, one from which steam is demanded in an almost fixed and unvarying quantity from one year's end to the other. This condition of boiler working is found in some pumping stations where the boilers have practically no other work to do but run the pumping engine that delivers a fixed quantity of water hour after hour. In such plants as these, the requirements are not so severe as in our rolling-mill plant, but the selection of boilers should not be made with any the less care, as, in most cases, such plants supply large communities with water, and a failure in the continuous working of the boilers menaces both health and property; the former depending upon a constant supply of good water for cleanliness, for drinking and cooking, while the latter depends on a large and immediate supply of water to extinguish fires. It is needless for me to argue further here the extreme importance of equipping a city water station with the very best installation that the city can afford, and one that will run for the longest period with the minimum amount of repairs. One that will present the best facilities for periodic inspection and thorough cleaning, one that will give the least trouble and prove the most economical in its consumption of fuel, is, without a doubt, the only equipment really to be considered for such very important service. Our mill engine, in most cases, runs for only a portion of the day, while our pumping plant is often operated during the entire twenty-four hours, month in and month out, thus affording practically no time to take care of any small leaks that may develop, which, if not stopped, are liable to become serious; and the quantity of fuel consumed in continuous and uninterrupted running amounts to large figures at the end of the year: it is, therefore, the poorest kind of economy to install, in such service as this, anything but the most economical working apparatus that can be bought. The first cost of a cheap, uncertain boiler is soon more than outweighed by interruption to constant and continuous service and a low rate of evaporation per pound of coal. I have seen certain boilers that have made an excellent showing immediately following their installation in a plant, but after a period of working, which may be as long as a year or two, their efficiency ceases and then is the beginning of their end. Boilers working under the constant condition just described are also found in ice-making plants, and others are used in connection with blowing engines, and in these plants their continuous operation is imperative, any stoppage being attended with no small loss.

We have now considered what might be called the two extremes of boiler practice, and between these extremes most boiler practice lies. Some may think that these two examples cover about all that comes within the consideration of the boiler problem, but I can assure you that the problems involved in the many applications of boilers to the work they have to perform is fully as varied as those met with in the selection of dynamos or motors. Before leaving this subject, I will give one other example, taking, for instance, the boiler equipment of an electric light station—a subject in which we surely are all deeply interested. Here, we find again in many plants, as in rolling-mill practice, a frequent variation of load, often changing in a moment from a small to a very large demand for steam. For this service, we cannot improve much upon our high pressure boiler already described, with its reducing valves, lowering the high boiler pressure to the lower pressure required for the most economical working of the engine. If we have a single cylinder engine, this lower pressure should be from eighty to ninety pounds, while with a compound engine, expanding its steam through two cylinders, 120 pounds has generally been found good practice. Passing steam through the reducing valve secures a most desirable result, aside from the mere reduction in pressure; that is, it either dries or superheats the steam delivered to the engine. A moment's reflection will assure us of this fact. We know that the total heat contained in one pound of saturated steam under 300 pounds pressure is 1,209.3 heat units, and as there is practically no external work done by the steam when passing through the reducing valve, this pound of steam, although reduced to a lower pressure, must contain the same number of heat units. Dry saturated steam at ninety pounds pressure we find contains only 1,182.9 heat units, thus we have

1,209.3 – 1,182.9 = 26.4 heat units in excess of what is needed for dry steam. As dry steam requires but .48 of a heat unit to raise one pound one degree, we find that our reducing valve will raise the temperature of the steam, at ninety pounds pressure, fifty-five degrees Fahrenheit above its normal temperature, provided the steam entering the reducing valve is dry. Should it, however, contain any moisture, this superheating effort will go towards evaporating the entrained moisture into steam. I have already described the operation of the high pressure boilers working with their reducing valves, and now, you will doubtless say, what saving can there be in fuel with this arrangement? In case our station has been working to its maximum limit and the load is suddenly diminished, the heavy fires carried in order to supply steam enough for our crowded engines will require some little time to burn down to the point needed to supply steam under our reduced conditions. Again, after operating the boilers to supply a light demand for steam, when a heavy demand comes suddenly, how can our light fires be brought up quickly to the intensity needed to meet the new requirements? These apparent difficulties can easily be overcome by using a mechanical induced draft, with a regulating device that will vary the intensity of the draft to suit the requirements.

As every one knows, combustion, in boiler practice, is controlled by the amount of air passing through the grates. As the supply of air is diminished, t
fire grows dull, and finally, when it is shut
entirely, the fire smolders and is soon extinguisl
The regulated mechanical induced draft
structed as to control the air supply o
and it works between wide limits of

very short interval. This device is constructed by simply placing a fan in the flue between the boilers and the chimney. This fan is driven by means of belting, by a small steam engine working direct upon the driving shaft, or by an electric motor. The speed of each of these driving devices is regulated by means of an attachment that is moved as the steam pressure varies in the boiler. very similar to the well-known action of the automatic damper regulator.

In 1887, I designed and put into service the first mechanical induced draft system ever used in this country, and, up to two years ago, I believed this plant to be the first one of the kind ever built and operated, but at that time I was brought to realize the truth in the old saying, "There is no new thing under the sun," as I learned that a similar application of a fan for inducing a draft was used in England some twenty or more years ago.*

Unfortunately for the general reputation of this appliance, a number have been installed in various sections of the country which have not been as successful as they might be, but careful investigation has proved to me, in every case that has come under my notice, that the whole trouble has been through inexcusable faults due, in many cases, to the sheer ignorance of those who designed and erected them.

The mechanical induced draft has been an unqualified success in too many plants to need any championing on my part, and, because a few ill-constructed plants have met with only partial success, there is no reason why the system should not be looked upon with the attention and favor it deserves. In designing this appliance, nothing should be done by guesswork, or the rule of thumb. It is a comparatively simple matter for a mechanical engineer to calculate very closely the volume of the gases to be handled by the fan after the combustion of a known quantity of any given coal. This being determined, it is then a fairly easy matter to calculate the size of fan required. The fan must be a large one, running with an average load at a comparatively slow speed. A small, high speed fan requires altogether too much power to operate it. The connecting ducts or flues must also be of ample proportion, that friction may be reduced to a minimum, and all possible turns and bends must be carefully avoided. Very rapid combustion, and hurrying of the heated gases through the boiler, is generally followed by a discharge of the gases at a very high temperature; and when these are excessively hot, their temperature should be reduced materially before they are allowed to escape into the chimney; this is generally accomplished with a very appreciable amount of saving, by using an economizer that consists of a series of cast-iron pipes placed vertically in the flue through which the feed-water for the boiler is pumped, and, in consequence, heated.

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* Since reading this paper, I have learned that the first induced draft was invented and applied by an American named Stevens, in 1827.

When a regular chimney is used, the maximum intensity of draft is secured when the heated gases escape into the chimney at a temperature of about 600 degrees Fahrenheit; but when the induced-draft system is in use, the temperature of the escaping gases has no influence on the draft, and, consequently, the lower the temperature at which these gases can be discharged, the greater will be the economy realized.

Some of you gentlemen may say that this induced-draft system, with its fan and economizer, is beginning to run up the expense of equipment, and that its cost will stand in the way of its introduction into electric light stations; but those who reason in this way have doubtless overlooked the fact that the large, costly chimney, necessary in the old plant, is dispensed with by this new system, and as the fan induces all the draft required for combustion, all we need in the way of a chimney is a short, inexpensive, wrought-iron stack, of barely sufficient height to discharge the gases at a point where they will not be a nuisance to the neighborhood. We shall now find that the money we would formerly spend for one expensive chimney will easily buy us our new apparatus, and it will surely prove, if properly designed and constructed, a far better investment than that massive shaft of brick and mortar. Some may want to stop me here and raise a question over these remarks. They may say that an old-fashioned chimney will, when once built, cease to be a source of expense, while the induced draft system will require steam for the engine to run it as long as it is in service. This is a point well raised, but careful investigation will show that the running expense is more than compensated for by the increased economy of fuel, due to the fact that not one pound more of coal can be burned than is actually required (due to the closely regulated air supply, which cannot be approached by the best automatic damper-regulating device ever made). Money is saved by the reduction of the discharged flue gases at a temperature lower than is possible when the regular chimney is used. The boilers can be made to develop a considerable percentage of power above their rating, and they can also be made to work below their rating with greater economy than otherwise possible. When the boiler house is located on treacherous ground, the difficulty and expense of securing proper foundations for the big chimney is left out of consideration.

Now, as for the power actually required to operate the engines of a properly constructed plant, investigation will show that it will require, at the outside, not over one per cent of the total power developed. In order to acquaint you with the details of the mechanical induced draft, with its regulating devices, I will describe the plant I have already referred to; the first one ever erected and operated in this country.

Figure 1 shows the front and side elevation and plan, which consists of five horizontal return tubular boilers and one vertical boiler, all having a total rating of about 600 horse-power. Examination will show that the main smoke flue, receiving the gases discharged from these boilers, is located directly above their rear ends; the smoke, etc., is conducted from the rear of each boiler to this flue by individual wrought-iron pipes or flues. After the discharged gases reach the main flue, they can travel in either direction, right or left, to the chimney, their direction of movement being controlled by the position of the two dampers, marked D, D, which swing on their respective hinges, H, H. By means of this regulation, the gases can be made to pass through the economizer, or, they can, without passing through it, be made to travel from left to right (see front elevation) and escape to the chimney direct from the opening at the extreme right.

The exit shows the damper at the left open, while the one at the right is closed. The gases thus travel from right to left, and then pass upward into the economizer. After passing through it, giving up their heat to the feed-water contained therein, they plunge downward at the right, into the outlet flue, whence they proceed to the fan, being drawn into it by its suction. After passing through the fan, they

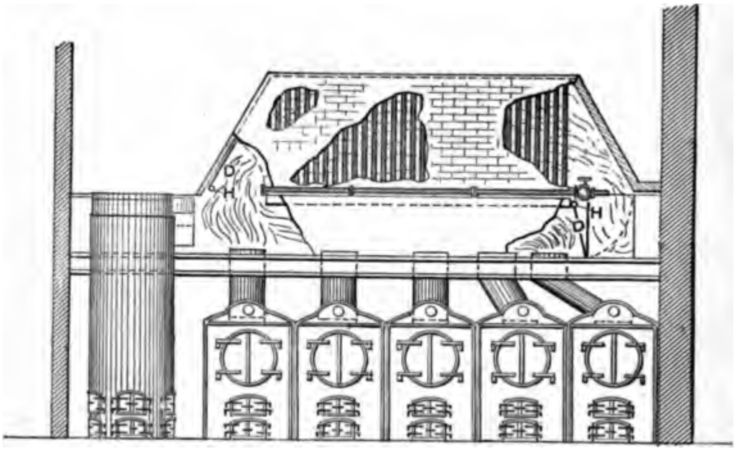

Fig. 1.—Front.

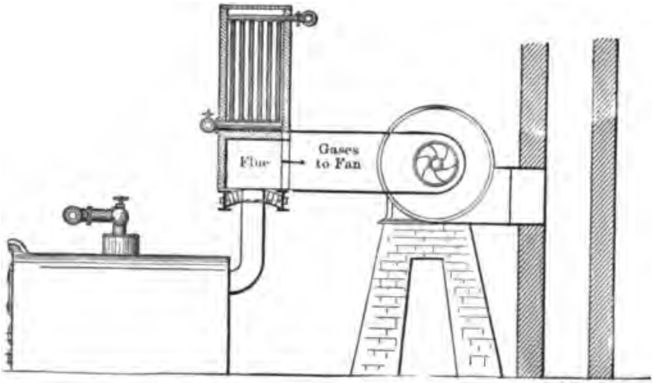

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Fig. 1.—Side.

are discharged, under pressure, up the chimney, whence they escape in the usual way. This gives a general idea of the working of this system, but we must also examine the details to understand the points which make it highly efficient. In the first place, I was obliged to devise a means to keep my bearings cool, and to make effective lubrication possible, as the heated gases had a tendency to raise the temperature of the shaft to a dangerous degree. I overcame this by using for a shaft a heavy six-inch weldless steel tube, and I passed all the feed-water for my boilers through it. Figure 2 shows the packed joint I used for this purpose, one being used at each

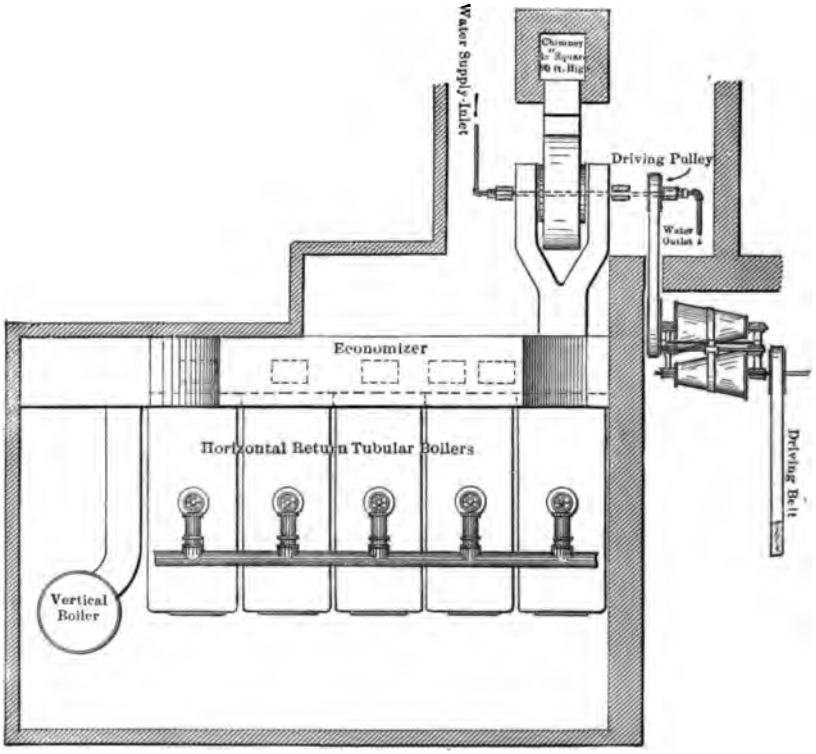

Fig. 1.—Plan.

end of the hollow shaft. This is merely an adaptation of the well-known piston-rod stuffing box, the soft packing being placed in the space marked C.

The speed-regulating device for the fan is shown in the plan view of Figure 1, and consists of a pair of speed cones, which cause the fan to revolve at different speeds as the belt connecting the two cones is shifted from one end to the other.

Figure 3 shows in detail the manner in which this belt shifting is accomplished. By examining the plan view, you will see that I place a screw above the centre of these two cones, carrying a nut, which, in turn, carries a belt shifting device. Of course, when the screw is revolved in one direction, the nut (which was prevented from revolving by means of a rod running parallel to the screw) will move in one direction along the length of the cones, carrying the belt with it. When the screw is revolved in the opposite direction, the nut travels in a reverse direction to that just described. The revolutions of the screw and its direction of turning are regulated entirely by

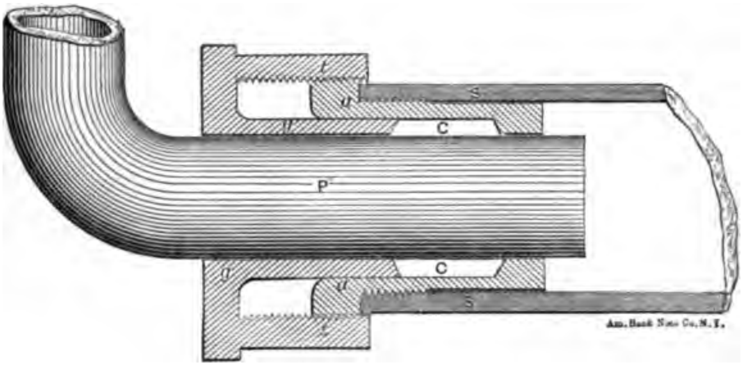

Fig. 2.

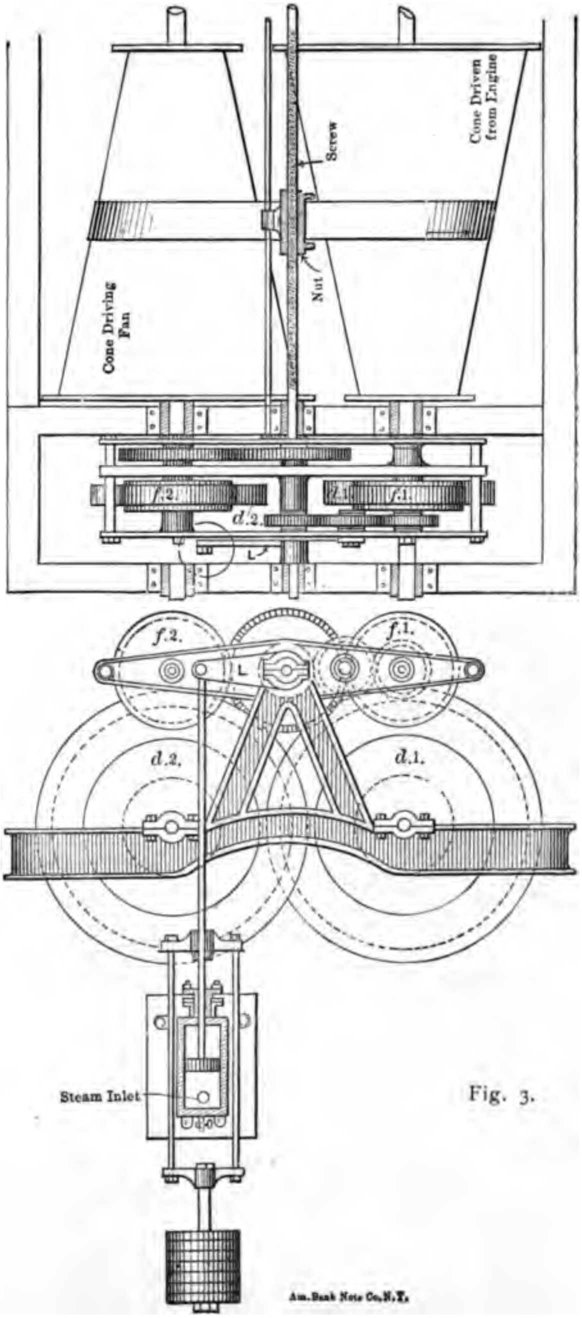

Fig. 3.

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gearing that is revolved by either one or the other of the two friction disks, f.1 and f.2 (see plan and elevation). One or the other of these friction disks is brought in contact with corresponding disk wheels located directly below them. Contact of f.1 with d.1 causes the screw to revolve in one direction, while contact between f.2 and d.2 causes the screw to revolve in an opposite direction. This alternate contact of the different pairs of friction disks is accomplished by means of a damper regulator (shown in position in the side elevation). The steam cylinder is here shown in section. The steam enters through the opening marked steam inlet, and if its pressure against the bottom of the piston is sufficient to overcome the weights (suspended from the cross-head on the piston rod), the piston will rise and make a contact between f.1 and d.1 by moving the "walking-beam" arrangement around the main screw shaft. If, on the contrary, the weights are able to overcome the steam pressure against the under side of the piston, the piston will descend, and a contact will be made between the friction disks f.2 and d.2, causing the screw to revolve in the opposite direction. Thus you will see that any drop in steam pressure will cause the fan to revolve more rapidly, inducing a greater draft and thereby intensifying the fire, while a rise in the steam pressure will produce just the reverse effect. In the plant under consideration, the speed of the fan had a range of from one hundred to 1,000 revolutions per minute.

There are many necessary considerations to be taken into account in the installation of a mechanical induced draft system, and one of these, of no small importance, is to provide means for preventing a sudden rush of cold air into the boiler when the fire doors are open for stoking or cleaning. Such an inrush, when the fan is revolving rapidly, produces a sudden chilling effect throughout the boiler, causing a great waste of fuel, to say nothing of the tremendous strains to which parts of the boiler are thereby subjected, causing, eventually, leakage and destruction.

To overcome this trouble, I introduced a device which is illustrated in Figure 4.

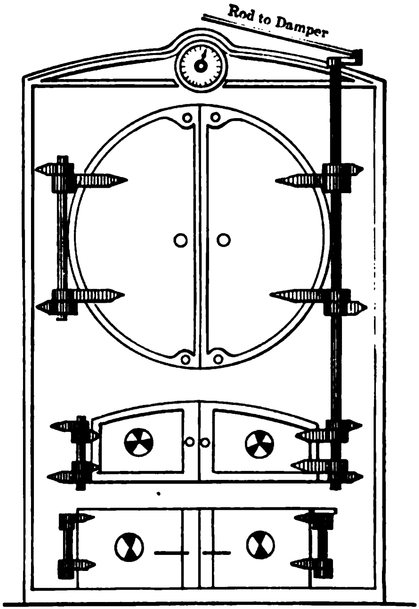

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Fig. 4.

The right-hand fire door overlaps the door on the left, and therefore had to be opened first. Through the hinge of this right-hand door, I placed a piece of gas pipe, keying it in place, so that it turned as the door was opened or shut. I continued this pipe upwards, above the top of the boiler, as shown, and on its top end I placed a crank, which was attached to a rod running back to the stem of the damper, this damper being placed in the individual flue connecting this boiler to the main flue. By this arrangement, when the door was opened for stoking or cleaning, the damper was closed at the same moment, thus accomplishing the results required.

I have made a number of other highly successful applications of this mechanical induced draft system, and new problems appear in almost every case. In applying it where a steam engine is connected directly to the fan shaft, I use this damper-regulating device in connection with a throttling governor, doing away, of course, with the revolving mechanism of the governor.

In case an electric motor is to be used, direct connected or geared, I use the same damper regulator, which operates a rheostat, through which the speed of the motor is governed.

Before closing this subject of regulated, mechanical induced draft, I would say that there are many electric light plants in which this system can be used to great advantage without the addition of the economizer, which will materially reduce the cost of installation. In some of these plants, we find the extreme maximum load lasting but two or three hours each day, and it will be merely during these times that the excessive temperature of flue gases exists.

After all, the matter of introducing any appliances to the steam plant resolves itself down to a simple commercial problem. Taking the matter of first cost and cost of installation, to which must be added the cost of maintenance, we can easily figure the interest on the investment. Next, after carefully considering the appliance, and securing, by personal investigation, the true results of others' experience, you can determine, with close approximation, the real saving the appliance will make to the plant. Next, balance up, and you will then be able to determine whether it is advisable for you to invest or not.

One of the most important considerations in designing an electric light station, is its equipment in such a manner as to secure the least possible interruption to continuous and unvarying service. In no place in the station should this consideration be heeded with greater care than in the boiler room. This is the very heart of the whole plant, and when anything happens to the boilers or their appurtenances, the entire station is affected and, in some cases, shut down. A little investigation will prove to you, when striking an average, that the stations provided with the best boiler houses are the ones that are showing the best economy, and such stations are the best dividend-payers. The situation of the steam plant is a matter of no small importance, and this is a matter, when choice of location is possible, that needs careful consideration. Carting fuel and ashes is a costly operation, and as much as possible of this should be avoided. Location on a navigable water front is most desirable, where coal can be delivered to the boilers with a minimum amount of handling. Location on a railroad is also a desirable situation, where coal cars can be run on a private switch to a convenient point for handling the fuel. A place, of course, should be provided for storing at least a fairly good supply of coal, and such stored coal should be well protected from sun and rain, as this protection will make a considerable difference in the value of the coal when burned. Certain progressive concerns occupying valuable ground space have recently had erected large vertical cylindrical iron tanks, in which they store considerable amounts of coal. Of course, the cost of ground space cuts a considerable figure in this choice of a location for a steam plant. It is easy, however, to compute the interest on the difference in cost between a most desirable site and one that is less desirable, and then calculate the difference in operating expenses in the two places. Room for extension must always be provided for. How many plants there are that have not considered this important matter, and have sooner or later found themselves badly handicapped in consequence. Good foundations are most desirable, but they are not always obtainable in a comparatively cheap manner. This is a very important matter, which should be carefully considered, and I have often found that it paid well to employ some one making a business of driving tube wells to prospect thoroughly an eligible site, and thus determine beforehand exactly the nature of the ground, and so get at, closely, the cost of the foundation work.

Recent practice in electric light stations has brought to the surface the question, when considering a station several stories in height, is it better to place the boilers in the basement or on the upper floors of the building? This is a matter of local consideration rather than one which could apply to all cases. Where the cost of real estate is high, and where good foundations for the building walls are obtainable, experience seems to point to the advantage of placing the boilers in the upper stories, thus leaving the lower story for foundations for the running machinery.

In designing a plant, one or more spare boilers should invariably be provided. Every possible accident should be carefully anticipated, and provision should be made to make even a partial stoppage of the plant impossible. In a small plant, no less than two boilers should be used, on the principle that it is not safe to "put all your eggs in one basket." In deciding how many extra boilers are needed in a plant, the ease and rapidity with which repairs can be made with the facilities *right at hand*, and with the special type of boiler used, should be considered. You must remember that you are liable to be called upon at any time—day or night—to get one or more of your boilers back into working condition again. Supposing you have a breakdown which can be repaired in a few hours, you can safely work the balance of your plant considerably above its rating for this short time, to help you through your trouble; that is, if the original rating of your boilers has not been placed too high. Ample heating surface is very telling under such trying circumstances. You should always provide for sufficient boilers to allow one or more to be laid off constantly for cleaning. The number of boilers provided for this purpose is governed greatly by the quality of the feed-water used and the care taken to purify the feed-water and make it fit for boiler use. The spare boiler for cleaning is a very paying investment where the available feed-water is bad, as it means the saving of very large quantities of coal.

Unfortunately, we find in many works on the steam boiler advice that can hardly be called sound. I refer to the advice given those who are about to select a boiler for their own use. These works tell you, quite properly, that all surrounding conditions must be considered, including the nature of the service in which the boiler will be operated. Thus far, the advice is good, and we find this followed by other sound advice, saying, the pressure under w the boiler is to be operated controls not a little the general design; but, finally, we read that the character or quality of the feed-water used is a large factor, controlling the selection of boilers, while some assert still further that the quality of the fuel used also needs consideration when choosing the form or type.

The bad advice given amounts virtually to the following: If you have bad feed-water, carrying much impurity, use a poor boiler; one that is acknowledged to be poor in economy of fuel. In other words, nothing is quite so good under these circumstances as the old, plain cylindrical boiler, into which you can climb periodically with a pick and shovel and remove the accumulation. Again, in case of bad fuel, the flues or tubes will pick up and accumulate the soot and dirt, so do not have any such miserable things about the boiler, notwithstanding the well-known and acknowledged fact that they promote economy and reduce materially the space required for the boiler plant. If this is called good engineering, I'm afraid that I do not know what good engineering really is. I will say, however, in defense of the authors of some of these works, that their books were written some ten or fifteen years ago, since which time the engineer and chemist have been hard at work, and have provided comparatively inexpensive means to remove the impurities found in boiler feed-water, or else to neutralize the worst part of the precipitated or other chemical matter so as to make it comparatively harmless in the boiler. By taking advantage of these means, you can now go ahead, in most cases, in the selection of your boiler, and equip with the most economical steam generator that can be found on the market. As for the conditions formerly ruled by the quality of fuel available, these need not enter into any further consideration, provided you will equip your boiler furnace with proper devices or construction to handle the fuel you have available. In both of these matters you will find that the trained and experienced mechanical engineer can help you not a little.

In selecting a site for a new boiler plant, the feed-water problem is one that must not be overlooked. A constant and never failing supply must, of course, be obtained, and if a supply from more than one source is available, every one should be carefully analyzed by a specialist in this line of work, and much money will be saved in the end by the pursuit of this course. Bad feed-water is a thing to be avoided, if such a thing is possible. I know of a certain electric light station, having somewhat over three thousand horse-power of boilers, in which it was thought that a considerable saving could be obtained by digging wells in the basement of the building and using this water instead of the city water supply, which was easily available. The well-water proved to be very bad, and it cost this company over twenty thousand dollars to find out what I have just told you. It will often pay you to go a considerable distance and run a line of piping to secure a good pure water supply.

The impurities contained in the water of large rivers is very apt to vary quite materially from time to time. This I found to be very true with the Mississippi River at St. Louis. This is not difficult to understand when we stop a moment and think of the immense territory this river drains. Local rains will find their way down the water sheds of their immediate vicinity, and, of course, they will dissolve and pick up such mineral matter as may be in great abundance in that section of country. In another section of country, where the character of the soluble mineral matter is very different, we find another and quite changed contribution to the Mississippi, while a storm near St. Louis, or very low water, will make the water very muddy. Probably the oldest method of taking care of the impurities found in boiler feed-water, is the use of a filter. There are many kinds of filters used for this purpose, but the principal ones may be brought under the following heads, for sake of classification—sand filters, block filters and cloth filters.

When water holds matter in mechanical suspension, it can be effectively removed by the process of filtration, as long as the filtering material is kept sufficiently clean. The great importance of keeping clean the material through which the water is passed being well understood, has led many inventors to produce what are known as "self-cleansing filters," which depend on processes more or less automatic, such as reversing the direction of flow of the water passing through the filter and causing the reversed current to flow with a considerable force and velocity. This will stir up the filter bed and carry the lighter impure matter to the surface, whence it is discharged with the water used for this washing purpose, the discharge being continued until the water runs clear. The sand, gravel or other filtering material, being too heavy to rise to the surface, after being turned over and over and raised some distance from its bed, falls back again to the bottom of the tank, ready for use as soon as the cleansing process is finished. Some filters are made to discharge upward, by means of a powerful jet of water, their entire filter bed of sand and other material. This passes up through a vertical pipe (more or less irregular in shape), until finally we find the entire bed deposited in a tank located immediately above the lower, regular, filtering tank. From this upper tank the material is allowed to fall, by gravity, back into the lower tank, and the process of elevation is repeated until the filter bed is thoroughly washed. The impure water resulting from this operation is discharged from near the top of the upper tank. Of course, it will be easily understood that the greater the amount of impurity held in the water, the slower the passage of the water through the filter bed must be, to accomplish desirable results. The nature of the material to be held back by the filter also affects the rapidity of the filtration. By this means, nearly all of the visible impurities of the so-called muddy water can be removed, but there are still left, in most waters, scale-making impurities, far more dangerous in a boiler than this ordinary floating matter. These are found dissolved in the water. A little investigation will prove that our purifier friends are after this matter as well as that originally in mechanical suspension, but, of course, in order to entrap it in their filters, they must first precipitate it, so that it will also be held in the water as floating matter, and, in order to do this, we find them using chemicals, which are fed in automatically (in most cases) along with the feed-water, the chemicals, of course, being dissolved in water before being introduced into the filter. In some cases we find the sulphate of alumina used, which precipitates the organic matter; the sulphuric acid it contains displaces the carbonic acid of the carbonate of lime, forming the sulphate of lime in solution (which, of course, will scale boilers badly). After this combination, the alumina is thrown down as the hydrate of alumina, in a flocculent, gluey mass, which adheres to the particles of dirt or other floating matter and, on settling, drags them down together, accomplishing a desired result. In order to produce this result, the water acted upon must contain an alkali to combine with the sulphuric acid, such as in the carbonate of lime and carbonate of magnesia, but the sulphate of lime or sulphate of magnesia will not be affected in the manner described. In the above reaction we have left the dangerous sulphate of lime in solution in our water, and, to take care of it, we must also introduce, along with our solution of sulphate of alumina, a solution of caustic soda (about one-half the weight of the sulphate of alumina). This will combine with the carbonate of soda, which, in turn, will act on the sulphate of lime, forming the sulphate of soda and either the mono-carbonate or bi-carbonate of lime, which is precipitated to the filter bed, where it is entrapped.

Sometimes we find lime-water fed into the filter along with the regular feed when the carbonate of lime or magnesia is dissolved in the water. The lime introduced combines with half the carbonic acid contained in the carbonate of lime or carbonate of magnesia, forming the insoluble mono-carbonates which are precipitated as floating matter, to be caught in the filter bed.

The above examples will give a general idea of the use of chemicals with filters, and we shall next find the filter men resorting to another method to precipitate the dissolved matter held in our feed-water, and that is, by the means of heat. It is a well-known fact that the carbonate of lime and the carbonate of magnesia are not able to retain their carbonic acid (which alone holds them in solution in the water) after their temperature is raised above 180 degrees Fahrenheit. The sulphate of lime and the sulphate of magnesia also become insoluble when their temperature is raised above 290 degrees Fahrenheit (this temperature corresponding to that of water under forty pounds steam pressure). Taking advantage of these facts, certain filter men first pass the water through their machines, then send it on to the boiler. Here it is heated considerably above the temperature that will precipitate the lime and magnesia. The next operation is to draw the hot water with its floating impurities from the bottom of the boiler and pass it again through the filter, which entraps the floating particles, thus taking them away from the boiler and preventing settling there of this scale-making matter.

The methods described above in connection with filter practice can all be found working with more or less success in many plants in this country. There is no doubt but that a filter is an excellent addition to many boiler plants, saving many times its cost in a comparatively short time; but it is certainly not applicable to all plants, and a thorough knowledge of the existing conditions should determine its desirability. In England and Germany we find a method of purifying feed-water that is but little known in this country, and it is a question of no small moment for engineers to decide whether this process, which has proved so successful abroad, would not prove equally valuable to our American plants, in which the character of the feed-water does not vary materially from that used on the other side. By this process large vertical tanks are placed near the boiler into which the cold feed-water is run. After it has been decided (by careful analysis) what kind and quantity of chemical or chemicals are needed, these are introduced in amounts proportionate to the quantity of water used, and a precipitation follows the chemical combinations made in a manner similar to the action just described in connection with filtration, but, in this process, no filtering takes place. Inside the vertical tanks are found a series of shelves placed in an inclined position and all sloping in the same direction. These shelves are often made V-shape, instead of being flat, thus sliding their contents down to one particular point. Opposite this point a pipe will be found leading out of the shell of the tank, and a straightway valve or cock opens or closes this pipe. This arrangement is found at the lowest point of each shelf, and all of the cocks are opened or closed at once by moving up or down a vertical rod. As the water flows from top to bottom of one of these tanks, the precipitation is thrown down on to these many shelves, finally sliding to their lowest points. As this sediment collects, from time to time, the vertical series of cocks are simultaneously opened, thus emptying all of the shelves of their deposited matter. By the time the water reaches the bottom of the tank, most of its dangerous impurities have been left behind, and so it enters the boiler in a desirable state of purity.

In this country we find the carbonates and sulphates of lime and magnesia in boiler feed-water quite successfully eliminated by the use of exhaust and live-steam purifiers.

Figure 5 shows the construction of this apparatus very plainly, which consists of a plain, cylindrical shell filled with a series of pans or shelves, which are easily slid out of the shell when the end cover is

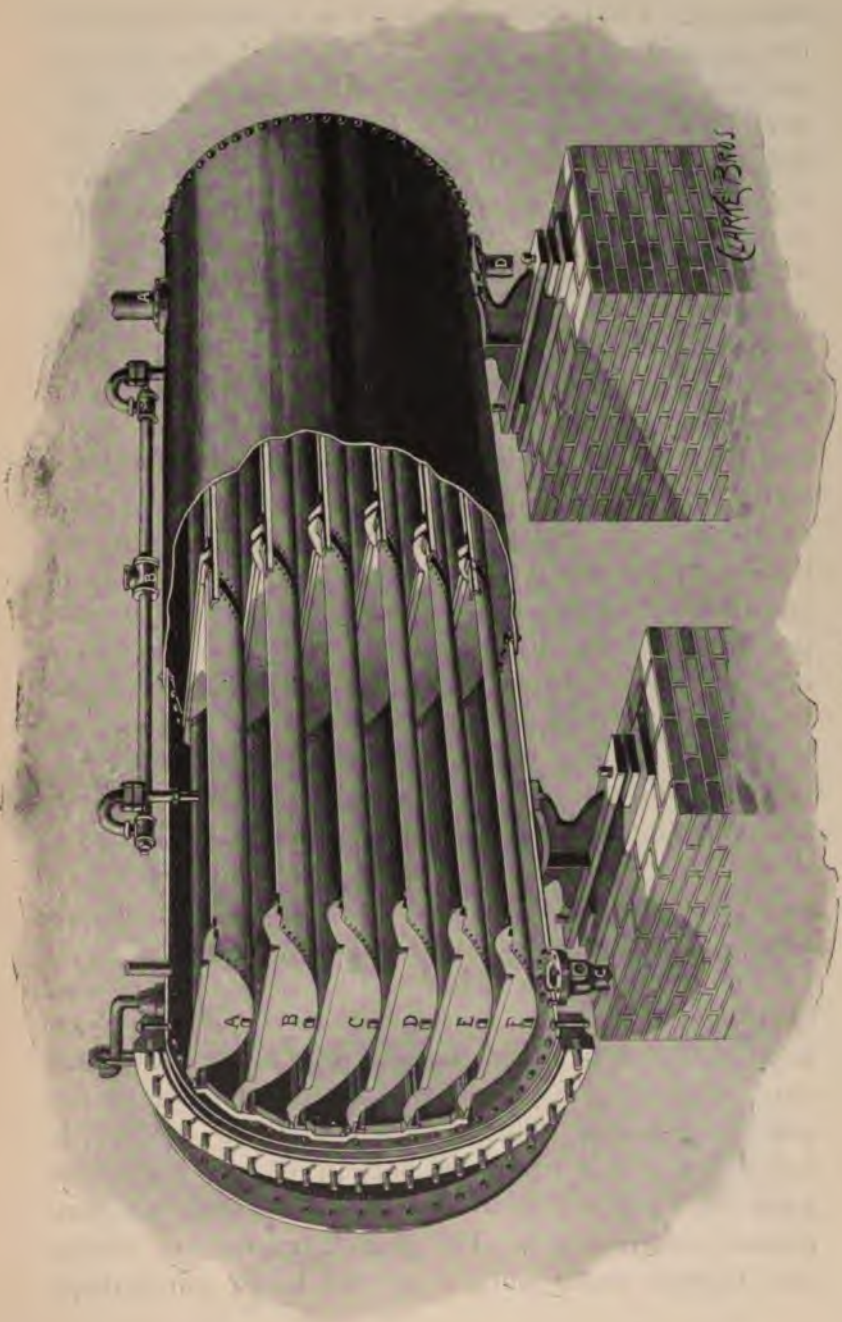


Fig. 5.

removed. The impure feed-water is introduced through the pipe B, flowing into both ends of the top pan. As soon as this top pan is filled, the water spills over its edges, falling into the pan below, and creeping along the under side of the top pan as it does so. As soon as the second pan is filled, the water finds its way, in the same manner, to the pan beneath it; and so it continues to the bottom of the tank, where it finds an exit at D, through which pipe it flows to the boiler. Steam is admitted into the shell at A. In the case of the exhaust purifier, the steam is supplied from the exhaust of the engine, in which case the water is heated to a temperature somewhat above 200 degrees Fahrenheit. In the case of a live-steam purifier, steam is supplied direct from the boiler, raising the temperature of the feed-water from 300 degrees Fahrenheit upward (according to the pressure carried). In the first case, the temperature of the exhaust steam raises the temperature of the water to a point where it is practically impossible for it to hold the carbonic acid which holds the lime or magnesia in solution; in consequence, these minerals are precipitated in the pans or along their bottoms. A similar effect occurs when the live-steam purifier is used; the sulphates of lime and magnesia are thrown down, collecting in and under the pans.

Figure 6 is the reproduction of a photograph showing the appearance of one of these pans removed from the purifier after it had been in use for forty-two days, while Figure 7 shows the same pan before being put in operation. The water-line in these purifiers is but a few inches from the bottom of the shell. Its pans are light and easily drawn out of their position, cleaned and replaced. The great advantage of having this deposit made outside of the boiler can perhaps

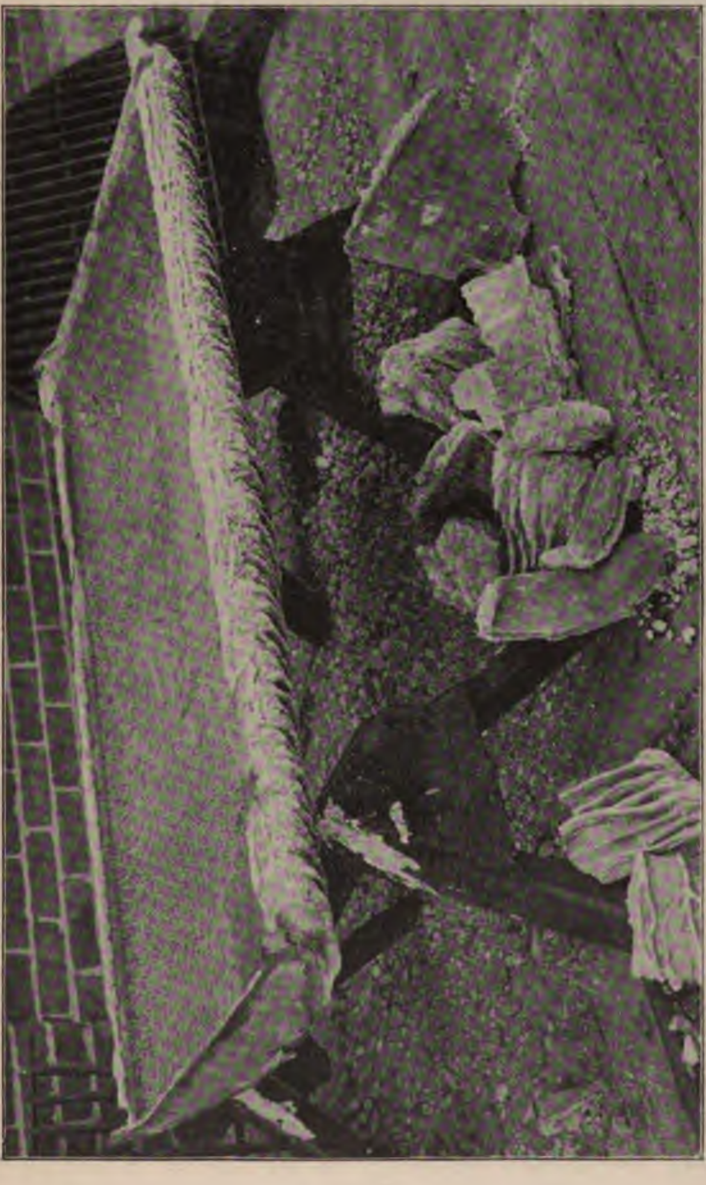


Fig. 6.

be realized by consulting the following table, which roughly gives an idea of the loss of efficiency in a boiler due to scaling:

Thickness of scale in inches,	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$
Loss of fuel, per cent......	2	4	9	18	27	38	60	90

There are many other methods in use for purifying boiler feed-water; some are very effective, while others have proved actually dangerous, owing to the faith put in them by boiler users while they are supposed to be performing their duty, whereas they are really allowing scale to form in the boilers; and, owing to the security felt in their presence, the usual care of the boiler ceases until trouble forces an investigation, and then trouble generally begins.

There are many "compounds" and "boiler fluids" offered to steam-users, which, according to the sales agents, will cure every ill the boiler is heir to. These should be accepted only after careful advice from an expert chemist, or from someone well experienced in treating feed-water, as I have known many cases where their use has been attended with serious results. It is as ridiculous to suppose that one special chemical or mixture will take care of every kind of boiler feed-water as it is to imagine that any one medicine will cure every one of our personal ills.

The matter of character of the fuel used affecting the choice of a boiler is the next subject needing our attention. In the modern boiler plant, the matter of fuel consideration becomes almost entirely one of furnace construction and management, and it has but little to do with the kind or shape of boiler used. In other words, the efficiency of the boiler is one thing, while the efficiency of the furnace is another; each standing distinctly by itself. If we have two fuels

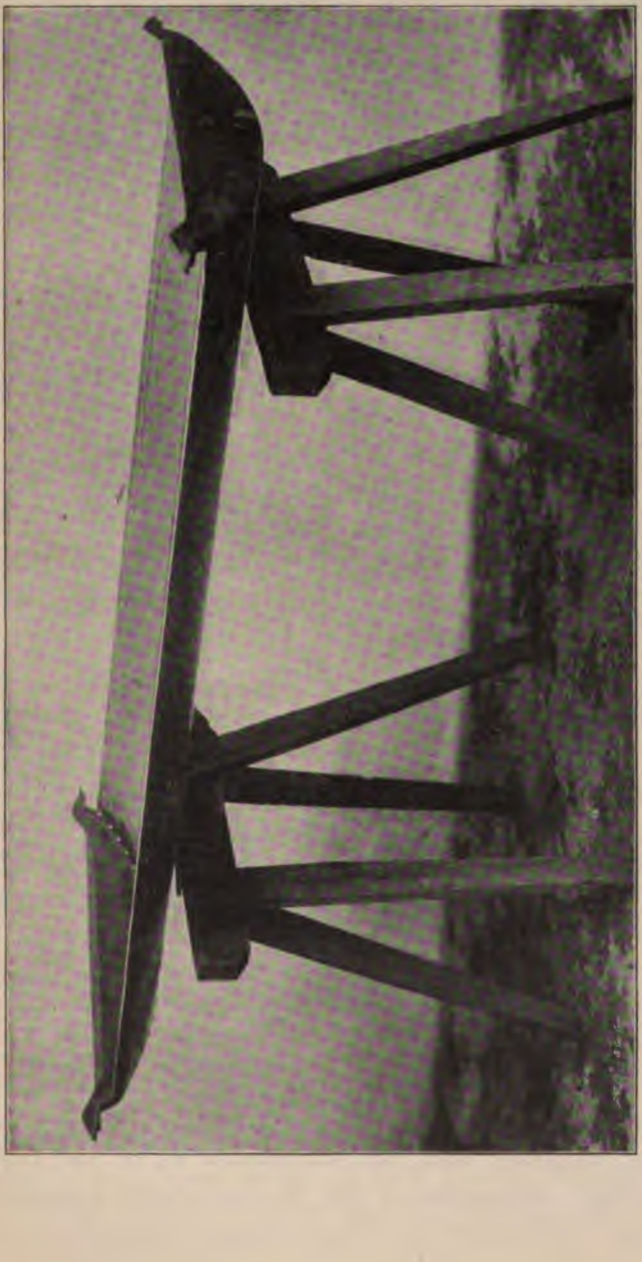


Fig. 7.

which differ from each other widely, and attempt to burn them in the same furnace and with the same method of handling, we often find that our resulting economy in one case is very good, while in the other it is very bad. By furnace construction, I do not refer merely to the kind of grates used and their immediate surroundings, but I refer as well to the difference in the general method of setting the entire boiler to meet the fuel requirements, and every change made between the grates and the flue. We have often found boilers built in certain sections of the country succeeding better by far with the fuels found in their particular section than any other boilers coming from a distance, and, with what has just been said, this is most easily explained. These special boilers are built originally with the idea of handling successfully the fuel near at hand. The setting is made to suit this fuel, the inventor being perfectly familiar with the experience he and others have had in getting the best results from it. The other boiler, coming from a distance, has not had this particular kind of fuel to deal with, and, therefore, until someone has become as well acquainted with the new fuel and new conditions as the inventor of the local boiler, and has been able to apply this knowledge to the setting and construction of the furnace, the local boiler is pretty sure to show much better results, notwithstanding the fact that the boiler from a distance, considered in itself, is far superior in many ways to the local one.

For many years the eastern makers of water-tube boilers have been badly handicapped in the West, owing to their lack of knowledge as to the furnace and other requirements for the successful handling of western coals, and for that reason, principally, many of the boilers built in the West, some of which are inferior to them from the points of design and construction, have succeeded in making an equal and even better record for economy. This can be traced simply to the superior methods of setting and the construction of the furnace, which are thus certainly very creditable to their originators. Of late years, these eastern manufacturers have, after passing through their school of experience, studied more closely the requirements of the western fuels, and have adapted their boiler setting and furnace conditions to suit the different coals found, and we are now beginning to find the eastern water-tube boilers succeeding well where they have not been highly successful before. These boilers are now being set with their tubes placed considerably higher from the grate bars, so as to provide a larger combustion chamber. We find them adopting the brick arch over their fires, so as to insure the more complete combustion of the light hydrocarbon gases before they leave the furnace; and we find them introducing air, more or less heated, above the fire, which also hastens the combustion in the furnace.

Many people recognize now that furnace construction is no small factor in securing fuel economy, and this has led to almost numberless inventions of special furnaces, the best of which are now being applied to all kinds of boilers; and economy of fuel and a decrease in the amount of smoke delivered from the chimney are resulting from their use. The selection of a furnace and setting for anthracite coal is, comparatively speaking, a simple matter. The distance from the grates to the lower part of the shell or the lower tubes of the boiler does not want to be as great as when bituminous coal is used. A good chimney draft and a high furnace temperature are required to burn anthracite coal successfully. Often, when ample chimney draft cannot be obtained, fans or steam jets are used to secure the required results. When fans are made to deliver their air under the grate bars, the best results are obtained from a flat-plate grate bar perforated with many conically shaped holes. A bar of this kind recently used by the author measured six inches wide by thirty-six inches long and one and one-fourth inches thick. It has one rib five-eighths of an inch thick, running along the centre and bottom of the plate, and was perforated with tapering (three-eighths to three-fourths of an inch) holes, spaced about one inch from centre to centre. These bars are more especially designed for anthracite coal running in size from pea down to No. 2 buckwheat. By the use of this grate bar, the forced blast, instead of being concentrated on one point of the grate surface, is forced to distribute itself evenly over the entire surface, thus preventing excessive heating at the one point and causing destruction there. Excessive clinkering often occurs with the use of this coal, the clinkers clinging tenaciously to the bars and side walls. This is sometimes remedied somewhat by occasionally throwing oyster shells into the fire with the coal, which fluxes the clinker and causes it to become more friable. Carrying water in the ash pit, also helps this trouble somewhat. The highly heated ashes dropping cause a steam vapor to rise and pass through the grate bars. The steam jet is often used with this fuel to great advantage, having a good effect on the clinker and keeping the fire-bed clearer and brighter. These steam jets are, of course, made to work beneath the grate bars, and are so designed as to induce and project a jet of air, and thus they displace the fan-blower for forced draft.

As the furnace temperature must be high to handle this fuel well, and as the fires must be kept clear and clean at all times, it is of advantage to use shaking and dumping grates, many of which are found on the market. Great care must be taken with anthracite coal, in order to get the best results, as to uniformity of size of lumps. Where several sizes are mixed together, the air space between any two adjoining pieces of the larger coal is filled, thus offering a very great resistance to the passage of air through the coal. The free and uninterrupted passage of air is most essential to obtain the best results. You should insist that your coal-dealer deliver you coal uniform in size, as this is very important.

There are two well-known automatic stokers built in this country made expressly to burn the small sizes of anthracite coal. One is of the endless chain pattern, receiving a continuous supply of coal on the end of the chain grate projecting outside of the furnace, and then slowly carrying this coal, burning on its way, to the rear end of the furnace, by which time the combustion is completed and the ash is automatically dumped into the pit below as the chain turns over its rear roller. The other stoker referred to consists of a series of inclined hollow grate bars. Each bar is but a few inches in width, and a number of these bars are found placed alongside of each other, filling in the entire space between the side walls of the boiler. The upper part of the bars project in front of the boiler front, resting on a saddle or bearing beam. Above the bars, at this upper point, will be found a hopper, which will hold a considerable supply of coal, and at the exit from this hopper will be found a revolving feed-wheel, the speed of which will regulate the quantity of coal fed to the inclined bars. The lower end of these bars, at the back and near the bottom of the furnace, is found resting on another bearing beam. In the front and upper end of each of these hollow grate bars a steam jet will be found, which, when in operation, induces a supply of air. The inclined bars are constructed with a series of slight steps. In the rise of each of these steps is found a slot whence the steam and air escape to the bed of fire resting on the inclined bars. The angle of inclination of the bars is somewhat less than the angle of rest of the coal, being about thirty degrees, and a downward motion of the coal along the grates is effected by a backward and forward motion of the grate bars (the motion being parallel to the boiler-room floor), every other bar being moved in opposite directions alternately by means of a series of eccentrics placed on a shaft in front of the boiler.

With the semi-bituminous coals carrying less than twenty per cent volatile matter, but little trouble is experienced in getting good results in the furnace. The distance between the grates and the lower tubes (or boiler shell) should be somewhat greater than when using anthracite coal. Most of the soft-coal stokers on the market can handle this coal advantageously, and, with proper care and intelligence, it can be fired with very little smoke. Bituminous coals carrying from twenty to forty per cent volatile matter require careful attention in furnace construction to obtain good results. The distance between the lower water-tubes of a boiler and the grates (when hand firing is used) should be increased materially, and a special furnace construction should be adopted when the best results are required. Where plain stationary grates are used. probably nothing will give better results than the fire-brick arch sprung over the grates; this arch preventing the immediate contact of the partially consumed volatile gases with the cool boiler parts, which contact results in the chilling of these gases below the temperature of ignition, thus causing them to escape, with their burden of soot, unconsumed. With the two last named grades of fuel, there are many special furnace settings and styles of grates on the market that give splendid results and prove excellent investments. The success of these has led a large number of men (who are hardly what we could call mechanical engineers) to invent and load on the market many curiosities in the line of special furnaces and settings, and, in consequence, steam-users should be very careful in their selection of these specialties, especially those that are new and untried. In the old, well-known automatic stokers, the character of the fuel to be used should be an important consideration in their selection, as one will handle one coal much better than another, and, therefore, the indorsement of a steam-user in one section of the country should not always be taken as a guide to aid you in the selection of a special furnace or special stoker, when you will use an entirely different coal in another section.

The stokers most used in this country may be classed as those feeding their coal to their combustion chamber, first, from each side of the furnace, toward the centre; second, from the front towards the rear of the furnace, and, third, from underneath the bed of fire, upward toward the boiler tubes, or shell.

Figure 8 shows the first method of delivering the coal. From this cut (which is a sectional view through the furnace) you will see that long boxes are built in the side walls of the furnace, running from the front to the rear, which are called the coal magazines. These magazines are kept full of coal during the entire time of operation. At the bottom of the magazine will be seen an inverted box (running also from the front to the rear of the furnace), and this is vibrated from right to left by means of racks and pinions, the result being that (from the centre magazine) the coal is first shoved into one furnace and then into the other. The coal next passes on to what is called the coking plate, where much of its volatile matter is distilled off by the heat, and this volatile matter is burned as gas in the intensely heated furnace. After this volatile

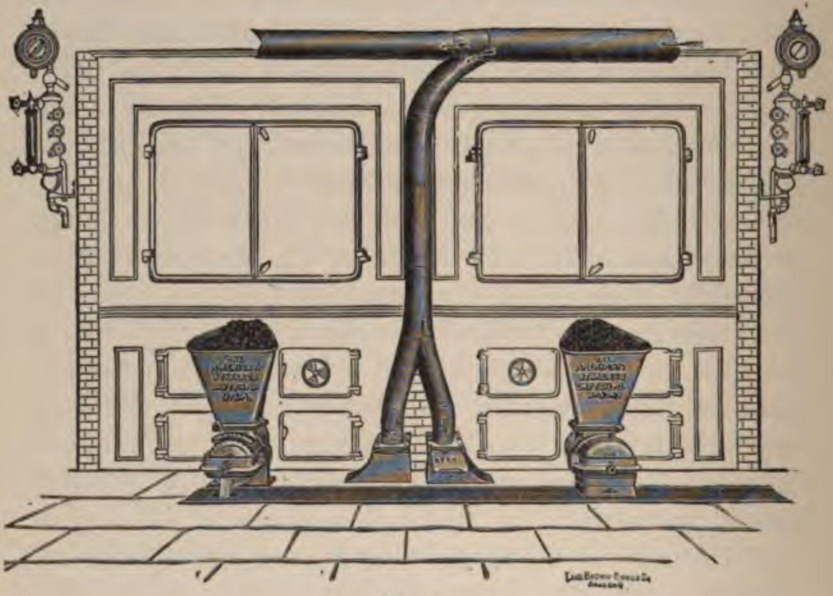


Fig. 8.

matter passes off, we have coke and the impurities in the coal left. The coke burns as it descends on the inclined grates, being assisted on its downward path by a slight motion given to the individual grate bars. At the bottom of the incline the ash and clinker fall on a revolving clinker-breaker, which grinds the solid part and delivers all the refuse into the ash pit below.

Figure 9 shows the second method of delivering the coal from the hopper to the furnace. This method of delivering the coal is very similar to that of a stoker already described. In this stoker, the coal is charged into the hopper running across the entire width of the boiler front. A pusher, with its feed plate (which forms the bottom of the hopper), moves in and out, shoving the coal from the hopper in on to the dead plate, where the coking process takes place, the volatile matter burning above the bed of incandescent coal, while the coke and incombustible matter descend along the inclined grate. On reaching the bottom, the ash and clinker fall upon a dumping grate, whence they fall to the ash pit below. Examination will show that the grates in this stoker consist of a series of steps running across the width of the furnace, and the burning fuel is impelled downward by a motion given to these steps which intermittently tends to tilt them all downward and form an uninterrupted inclined plane.

Figures 10 and 11 show the third method of delivering the coal to the furnace; *i. e.*, from the bottom of the bed of fire upward, and it operates on the gas-producer principle. This is a much younger stoker than either of those just described, but its great recent success is fast pushing it to the front, and gaining it a well-recognized position. The

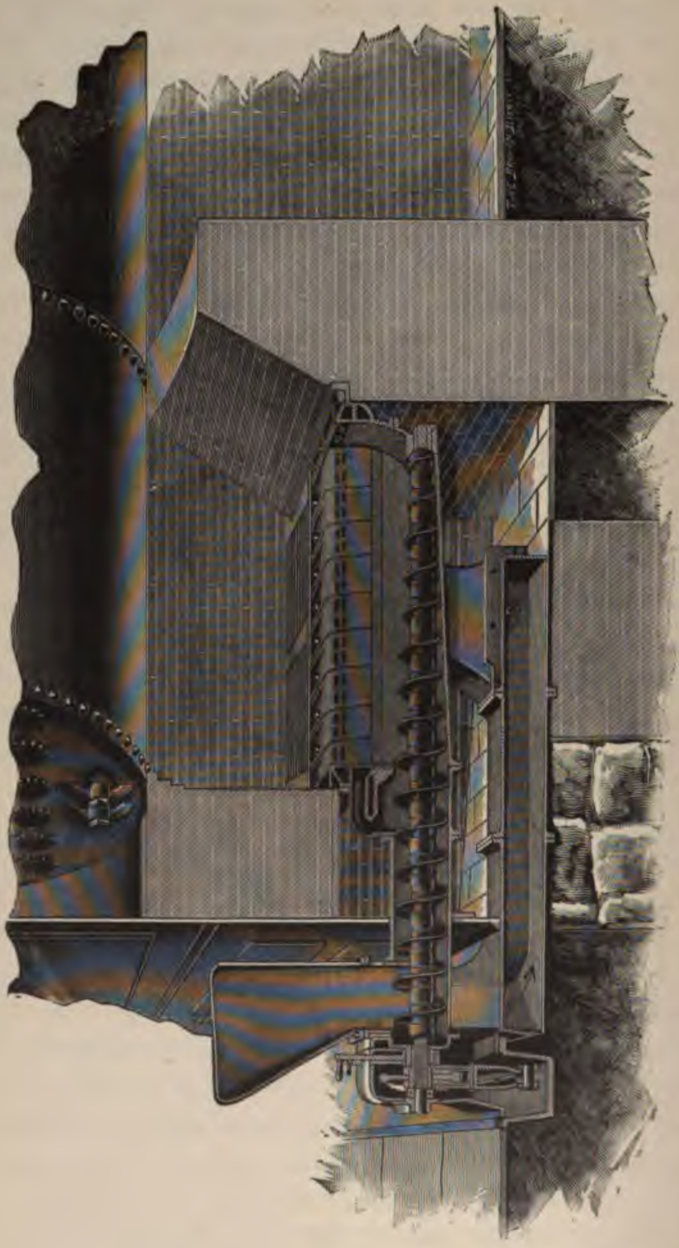


Fig. 9.

regular stationary grates are used in the furnace under which this stoker is applied, these covering about one-third of the distance (measuring across the width of the furnace) from each side wall. This will leave us about one-third of the width of the furnace throughout the entire length, and in the centre

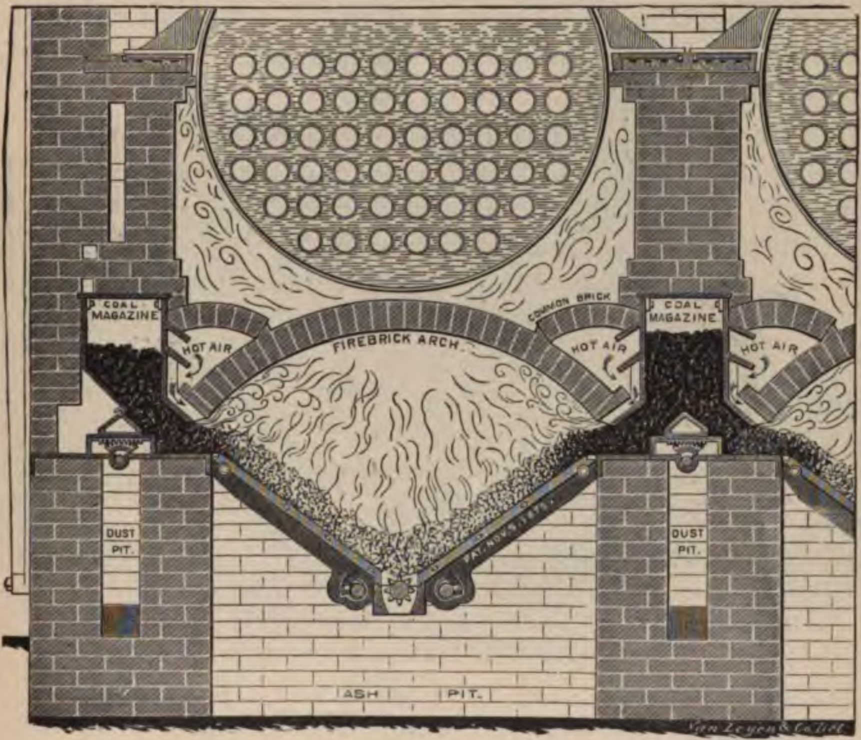


Fig. 10.

entirely open, and into this opening the stoker is fitted. Next to the stationary grates on each side of the central opening, tuyere blocks are placed, and under them is found the wind box, which furnishes the tuyeres with their supply of air, this supply coming from a pressure fan placed outside. A U-shaped trough is made to drop from the tuyere blocks on each side, running from the front to the rear of the furnace, and thus we have the central space between the side grate bars entirely filled in. This trough is continued through the front of the boiler,

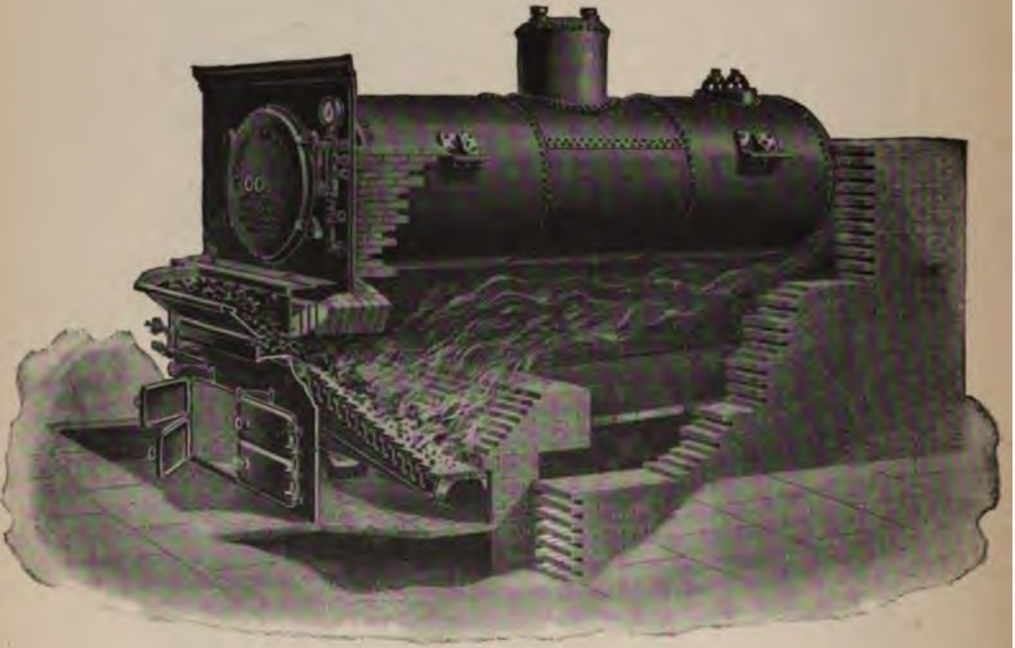


Fig. 11.

but when passing through the front, it changes its shape to that of a cylindrical pipe, and, finally, it ends directly under a hopper or tank into which the coal is charged. Along the bottom of this trough a screw is placed, tapering gradually from the front to the rear. This screw is moved intermittently by a ratchet and pawl motion, similar to that found on a ratchet drill. Let us now suppose there is a bed of fire covering the entire surface of the furnace. Coal, after being got into the hopper in front of the boiler, falls upon this screw, and as this screw revolves the coal is fed into the U-shaped trough. This being full, the coal finds its easiest path of escape upward, and, in consequence, we find a long mound of coal heaped up in the centre of the furnace, over the trough. The double row of tuyeres on each side of the trough supply the upper part of this mound of coal with air, hastening combustion, while the coal in the bottom of the trough is unable to burn until it rises to the zone supplied with air, and here the incandescent bed of coal above distills the volatile matter so that it rises, as a gas, passing upward through the intensely heated fuel, burning completely before it reaches the surface, and thus we have a practically smokeless combustion.

After the volatile gases are distilled off from the coal, we have, practically, a coke left, and it is this coke that burns so fiercely on the upper surface of this mound. After the coke is consumed, the refuse, in the form of clinker, rolls down the sloping sides of the central mound on to the side grates, from which it is removed through doors in the front of the boiler. It seems strange to many, when watching the operation of this stoker, to find that there is practically no ash left behind; everything in the way of non-combustible goes to form clinker, and, of course, no "black bugs" (unburnt coal) are found in examining the refuse drawn from the furnace.

We have now considered the principal forms of automatic stokers found on this market, most of the others resembling them more or less. We last spoke of a bituminous coal running from twenty per cent to forty per cent volatile matter. When a coal contains over forty per cent of volatile matter, it should be burned in a furnace almost entirely surrounded with fire-brick, and the nearer we get to an actual gas-producer, the better will be the results obtained. A very large combustion chamber should be provided, and air should be introduced above the fire, heated to as high a temperature as possible.

I have said nothing about the consumption of smoke, as it is popularly termed, without reason. I do not consider it necessary to touch on this subject after what I have said about furnaces and special setting, as that covers all worth considering in the matter of smoke prevention. In other words, burn your coal properly at the start, and the smoke nuisance will be abated in direct proportion to the adaptation of your furnace and setting to the coal you are using.

There are an almost countless number of topics connected with steam boiler engineering, any one of which could be taken up here and discussed with much profit and interest, but there are only one or two other matters that I will touch on here.

The first has already been brought before you at your Buffalo meeting, in 1892, in an excellent paper by Mr. Richard Hammond, entitled, "How to Fire a Boiler." In this paper, Mr. Hammond says: "It is often the case that firemen are paid insufficient wages for the work they are expected to do. We should be as particular to have good firemen in charge of our boilers as we are in having good engineers in charge of our engines." Do not forget this most excellent advice. Do not think that anyone who can handle a shovel is good enough to be your fireman. You cannot get something for nothing, and a good fireman commands good wages. He can save you as much in his own department as any one in your employ, and remember that your whole plant is depending on him and the result of his work for its successful and continuous working. Your boiler room can be kept as clean and attractive as your engine room. If you wish to work to the best economy, keep a careful record of your boiler plant in a daily log, which will show you just how much coal you burn each day, and occasionally test your boilers and find out just about how much water each pound of coal is evaporating. I know of one concern having a large tank standing back of their boiler house, it being some fifteen feet in diameter and fifteen feet high. This was bought second-hand at about the junk price of the metal. This is filled up once a week, and the weight of coal required to evaporate its contents is easily obtained by running the wheelbarrow loads over a common platform scale. This is an easy commercial test to make, and, although not scientifically correct, it is near enough for a practical comparison of economy obtained with different coals, and at intervals with the same coal. In keeping a log, an entry should be made at regular intervals of everything connected with the working of the plant. The temperature of the feed-water should be carefully noted and also the steam pressure. I am sorry to say that recording steam gauges are not used as much as they should be. No first-class plant should be without one. They tell big stories sometimes, and indicate pretty nearly how the plant is being run.

THE PRESIDENT: We have present with us Mr. Thomas W. Flood, Commissioner of Wires in the city of Boston, who will say a few words to the convention.

MR. FLOOD: Mr. President and delegates of the National Electric Light Association:

Let me first thank you for the honor you have conferred upon me during my stay here, representing as I do the electrical department of the city of Boston.

As many of you are doubtless aware, I am only an infant in my present position, and a mere novice in the great business in which you gentlemen are associated. Practically, I know nothing about it at present, but I hold the office of Commissioner of Wires, and execute the business of that department so far as my knowledge of things goes. I allude to this simply so as not to be misunderstood when I address this convention.

As I have previously stated, while I know nothing of electrical matters in general, we have in our city a few gentlemen who do know considerable about them. As a great municipality, Boston has, at all times, the proud pleasure of being the first to throw all the light possible on any subject of public interest. She stands there to-day, and she is represented in this convention in the person of Captain William Brophy, whose reputation as an electrician is well known throughout the country, and of whom Boston is particularly proud.

We have, of course, many others well versed in electricity, but as yet I have not had the pleasure of meeting them all, but I wish to allude to my friend, Mr. Edgar, vice-president of the Edison Electric Illuminating Company, who ought to know at least something about this matter. Then, there is the good-natured president of the Boston Electric Light Company, Mr. Gilbert, whose knowledge is increasing daily; there is also a gentleman by the name of Ayer—and that floats around everywhere, you know—who is getting to be an adept in his line.

I do not desire to intrude further on the time of the convention, except to say that I should like at some time to become a member of this organization, in order that I might participate in its discussions.

I remarked to my first lieutenant the day before yesterday, that I should have liked to take part in the discussion opened by a gentleman named De Camp, where he was chairman of a committee appointed fifteen months ago, and had no report to make, which was participated in by Judge Armstrong and another gentleman named Beggs. It would have given me a great deal of pleasure if I could have taken part in it.

A voice: He wants a scrap. (Laughter and applause.)

The meeting then went into executive session.

EXECUTIVE SESSION

The nominating committee presented the names of the following gentlemen for officers for the ensuing year:

President, Frederic Nicholls, Toronto, Canada.

First Vice-President, Henry Clay, Philadelphia, Pa.

Second Vice-President, J. J. Burleigh, Camden, N. J.

Members of the executive committee to serve until the close of the twenty-second convention:

A. J. DeCamp, Philadelphia, Pa.

John A. Seely, New York city.

A. M. Young, Waterbury, Conn.

To fill the unexpired term of J. J. Burleigh, H. A. Wagner, of St. Louis, Mo., was nominated.

Mr. Armstrong: I move that the polls be declared open for the election of officers.

Mr. Browne: I was going to suggest that our retiring president be authorized to cast the ballot of the association for the gentlemen named.

Mr. Armstrong: I don't see how you can do that.

Mr. Browne: We appoint the president our proxy, and ask him to cast the ballots for us. I move that he be authorized to do this.

Carried.

The president cast the ballot, and declared the officers duly elected.

The President: Before closing, I should like to say that I feel very much gratified at the way in which this meeting has gone off. I expected that holding a convention in New York would be practically the same thing as giving the electrical managers and their friends, with our other members, a vacation for a period of a few days to look over the beauties of the city; but, on the contrary, we have had a very full meeting, and I want to thank you all for your attendance.

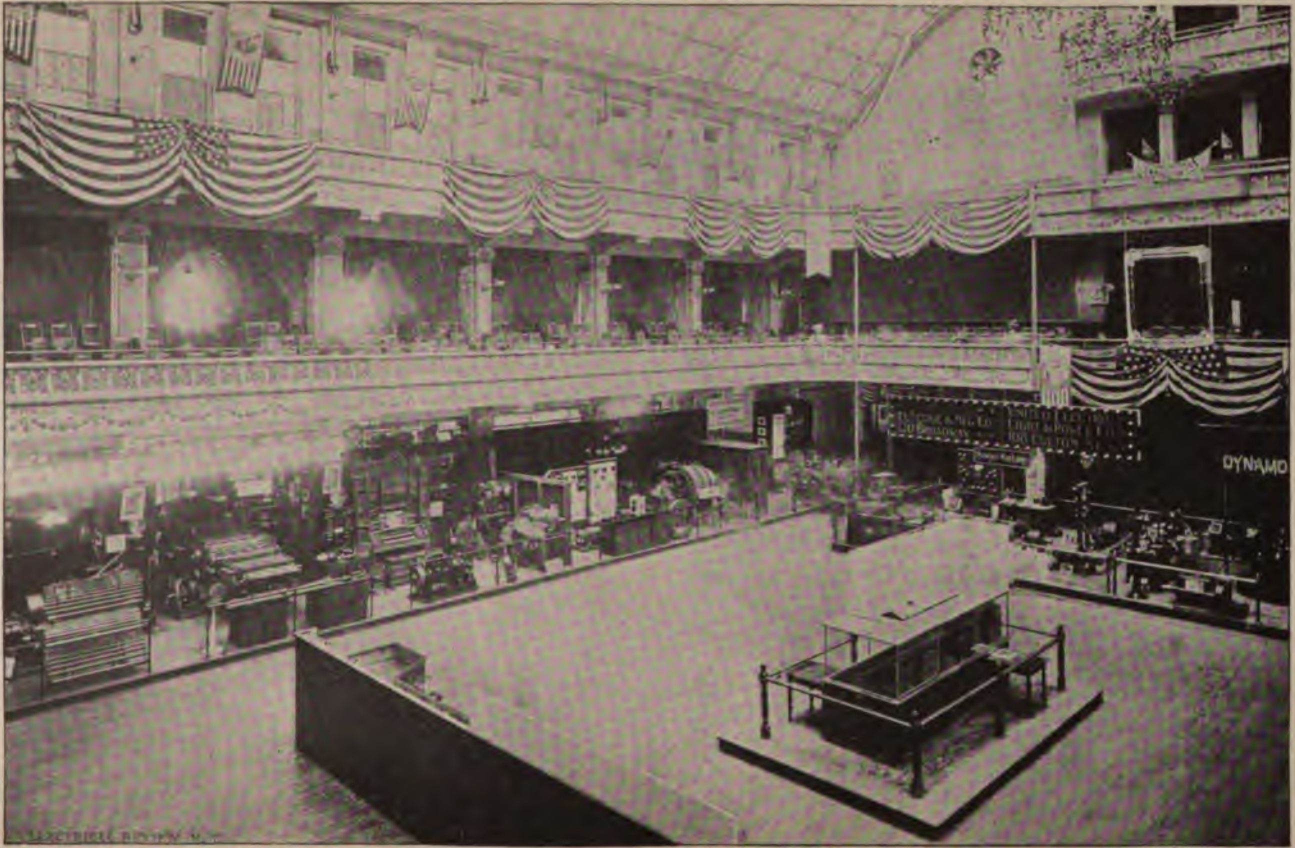
MR. SEELY: I move that the secretary be instructed to prepare a suitable set of resolutions, and present them to the retiring president, which shall express our appreciation of the able manner in which he has directed the affairs of the association during the past year.

PRESIDENT-ELECT NICHOLLS: I have very much pleasure in putting that motion, gentlemen.

The motion was carried.

The meeting then adjourned, *sine die.*

THE NEW YORK ELECTRICAL EXPOSITION
OF 1896.



The Electrical Exposition—View of the Main Floor Looking From the Gallery—Miniature of Niagara Falls and Telephone Listening Booth in Center, and Model of Erie Canal in Foreground.

Illuminated Frame occupied by Gov. Morton, Opening Night.

THE NEW YORK ELECTRICAL EXPOSITION OF 1896.

Ever since the organization of the National Electric Light Association, it has been the custom of manufacturing companies and supply houses to seize the opportunities presented by the conventions as a means of bringing their products and specialties before central station managers. This natural and commendable practice has resulted very beneficially to all concerned, and the exhibit of apparatus is to-day one of the leading features of every convention. At the same time, there has always been a feeling on the part of the officers of the association that its work lay also in reaching the public as directly as possible and in convincing it, by object lessons, that electrical appliances for light, heat and power were now readily available by everybody. At Boston, in 1887, the exhibit of electric motors, at the convention, thrown open to the public, did much to stimulate the use of current for power. The exhibit at Chicago, in 1889, is generally regarded as having done great good in popularizing the newer arts of light and power throughout the West. The visit of the association to Montreal, in 1891, was marked by an exhibition larger than any before attempted under the auspices of the association, and its brilliant popular success and utility are matters of history.

Within the last year or two, the tendency to depend upon central stations as reservoirs from which to draw current, no matter what the purpose, thus bringing into closer touch and union than ever all the widely scattered electrical arts, has created many new problems for central station managers, and has thrown upon them many new responsibilities. The idea, at first casually and idly talked about, of presenting in a great exhibition this new and interesting condition of things, hardened slowly into a conviction among earnest members of the association that something of the kind ought to be undertaken, if only as a matter of duty. No such great exhibition had been held in this country since that given by the Franklin Institute, of Philadelphia, in 1884, and it was argued that the success then achieved would be more than duplicated if a body with the dignity and authority of the association would lend its name and influence to an exhibition to be given in New York city.

Discussion and agitation of the subject crystallized at a meeting of the association's executive committee, held in New York on May 4th, 1895, when a special committee was appointed to investigate and report at a subsequent meeting. While the object was regarded as laudable, the committee did not know to what extent such an exhibition would be supported by the electrical manufacturers and trades, and it doubted seriously the advisability of pledging the resources of the association to an enterprise which, however desirable, would involve considerable risk and expense. On September 10th, 1895, a report submitted at the meeting by the secretary showed that a very large percentage of the associate members of the association, interested in supplies, were in favor of holding an electrical exhibition on a large scale, while the other moot point, that of financial management, was met by the suggestion to license a company to carry the plan through at its own risk, but under the close control and supervision of the association. It was accordingly decided to appoint another committee, consisting of Messrs. Seely, Peck and De Camp, who were clothed with full power to negotiate with a company to be formed for the purpose of conducting the exposition, and to contract with such company for carrying out the enterprise under the auspices of the association and in a manner that should yield it a certain revenue for its regular work. This committee reported again to the executive committee that a contract on the lines here indicated had been executed between the National Electric Light Association and the National Electrical Exposition Company.

It will be noted that this brief record of events brings down the date to the middle of September, in 1895, and as it was the intention to hold the annual convention and the exhibition in New York, in May, 1896, there was evidently a minimum of time within which to organize such a display as the officers of the association and the gentlemen now co-operating with them for this special purpose had in mind. Moreover, trade conditions were extremely bad, and theatrical managers reported, and proved by their frequent collapses, that the public had no money to spend for amusement, particularly for that brand of it which aimed also at scientific instruction. But there were redeeming features in the case, not visible to outsiders, though noted by careful observers and greatly depended on by the more sanguine members of the association. In the first place, an ideal site for the exhibition was chosen in the Grand Central Palace, a huge six-story fire-proof building on Lexington Avenue, covering the block between Forty-third and Forty-fourth streets. Peculiar facilities were offered here for the grouping of exhibits by their natural classification, and for the arrangement of special features, such as lectures and scientific experiments and entertainments. In the second place, New York, with its four millions of resident and suburban population, was unfamiliar with the later electrical wonders, and through the press manifested the utmost eagerness to know what the show was likely to consist of and exemplify. These being the circumstances, work was pushed forward boldly and vigorously, and the opening of the exhibition on May 4th found everything in a remarkable state of readiness. It has become proverbial that exhibitions are never ready on time, but, in this as in so many other respects, the New York Electrical Exhibition of 1896 was a record breaker. The two facts, that the building was ready and waiting, and that the exhibition would last a bare month, combined to exert a pressure on exhibitors to be in line and on time when the doors were thrown open to the public, and the result was that while many additions were made during the period of the exhibition, the display as a whole was complete from the outset. The fact that 35,000 people attended the show during the first week, and in increasing numbers thereafter, speaks for the condition in which they found it and for the manner in which even the most glowing popular anticipations were realized.

The exhibition was declared open by Governor Morton, of the State of New York, on the evening of May 4th, in the presence of an audience of over 10,000 of the representative people of the city. He was assisted on this occasion by President Wilmerding, Mayor Wurster of Brooklyn, and the officers of the association and the company. Guns were telegraphically fired at the same instant, by touch of key from the hall, in several of the larger cities all over the union. The Governor used for this purpose, as well as to start the machinery, the golden key that was pressed by President Cleveland in starting the World's Fair at Chicago, in 1893; and the base of the key, which is religiously preserved by General E. S. Greeley, its owner, has been lettered with the additional record. Governor Morton also stood, while the ceremony was going on, within a huge frame composed of the vacuum tubes of Mr. D. McF. Moore, which, with other like devices, were switched into circuit at the right instant so as to illustrate the beauties of that new method of electric illumination.

Three floors of the Grand Central Palace were occupied by the exposition thus brought into being and made an actuality by the influence of the association and the efforts of a few public spirited men enlisted for the occasion. About 80,000 square feet of floor space was divided among more than 200 exhibitors and the special auxiliary exhibits included for purposes of education and instruction. The list of exhibitors, and the floor plans printed herewith, will show that hardly a single electrical concern of any importance was unrepresented, but that, on the contrary, the great telegraphic, telephonic and other interests joined hands cordially with those of lighting and power to make the demonstration comprehensive and complete. The special features of the exhibition within the scope of the work implied by the name of the association, were the remarkable display of direct-connected units; the exhibit for the first time in public of vacuum-tube lighting for all purposes; the large modern dynamos for arc lighting;

the multiple arcs and inclosed arcs; the high voltage incandescent lamps; the use of the storage battery in lighting; the exemplification of electric cooking and heating, and the endless illustrations of the flexibility of electric power. All these elements were of vital interest to the central station companies or the owners of isolated plants, and were carefully studied.

A brief reference must be made to the many features of special novelty and interest that did so much to make a brilliant success of the exhibition. It was early deemed advisable to illustrate the evolution of the electrical arts by models and apparatus, and to secure the loan of relics of the pioneer days. To this end, Mr. T. C. Martin was asked to serve as chairman of the Historical and Loan Exhibit Committee, and to him and his associates, Dr. Park Benjamin, the historian, and Mr. E. L. Morse, son of the inventor of the electro-magnetic telegraph, full powers were given to organize this department. Dr. Benjamin responded by making a superb exhibit, from his famous library, of several hundreds of the earliest books on electricity, or those making mention of it. Mr. Morse contributed a large and unique collection of models, letters, pictures, statuary and relics relating to the beginnings of the telegraph. Mr. Martin undertook to bring in the work and treasures of other pioneers and inventors, and when its labors bore fruition, the committee had placed exhibits of priceless value in spaces aggregating not less than 10,000 square feet, and comprising special exhibits from the United States Patent Office, Mr. Thomas A. Edison, Prof. Elihu Thomson, Dr. R. O. Doremus, Dr. M. I. Pupin, Miss Mary Henry, J. W. Mackay, Jr., S. Vail, Dr. W. J. Morton, and such institutions as Cornell University, Stevens Institute, the University of New York, the College of the City of New York, etc.

Part of the work of this committee included also the securing of such remarkable exhibits as the transmission of the energy and the very roar of Niagara, from the Falls right into the exhibition hall, and the demonstration of the Röntgen X ray by Mr. Edison. With regard to the first, it may be noted that as soon as the exhibition project was outlined, Mr. Martin made the suggestion that thus to bring Niagara to New York would be an attractive feature; and as soon as definite plans as to date and place had been made, he undertook to secure all the facilities. The scheme encountered much skepticism, but Mr. Martin won the co-operation of President E. D. Adams, of the Niagara power enterprises; the advice on technical points of Mr. Nikola Tesla; the promise from General Eckert and Mr. A. S. Brown of two Western Union wires to carry the power current; a like promise from Vice-President E. J. Hall, Jr., and Mr. F. A. Pickernell, of the American (Long Distance) Telephone and Telegraph Company, to transmit the "roar of Niagara;" the aid of the Westinghouse Electric and Manufacturing Company and Mr. L. B. Stillwell, its engineer, in building a small Tesla two-phase motor to receive the current; and from the Honorable Peter A. Porter a large model of Niagara Falls and the power plant (twelve feet by four), whose turbines were to be run by the motors. Obviously, it was no easy task to bring about the joint working of all these forces, but from the very outset of the exhibition the idea proved to be not only a success, but a great centre of attraction. The distance of transmission was over 460 miles, and direct-current motors, as well as the two-phase, were driven. The telephonic transmission from the American Fall was not less successful, as will be seen from the official report of the operating company appended hereto.* It was one of the "sights" at Grand Central Palace to watch the endless line of people waiting to put the telephones to their ears, around the working model D.

Mr. Edison's X-ray exhibit was unique, nothing of the kind ever having been attempted before. Indeed, it far exceeded in its scope what was intended primarily when Mr. Edison promised Messrs. Porter and Martin, who waited on him officially for the purpose, to show his fluoroscope and to give an opportunity to everybody to test the penetrating qualities of the ray. So many difficult problems were encountered at the outset as to the disposition of the apparatus, and the handling of it, in a crowded building and with a dense throng eager to see the new wonder of scientific discovery, that Mr. Edison turned over the arrangement and management of the whole thing to Mr. Luther Stieringer, to whom he loaned the services of several of his best experts from the laboratory. A special dark chamber was devised by Mr. Stieringer, with a little laboratory annex and retiring room, and Mr. Edison himself assisted in all the preliminary work of getting the apparatus in such shape that thousands of people could make experiments for themselves and with themselves, in regard to a delicate and subtle phenomenon. The result was most gratifying and satisfactory. As a matter of fact, the exhibition was very useful in enabling so many persons, at a time of great excitement over the subject, to get a trustworthy idea of what the X ray could actually do, and thus helped to give the new discovery its place in physics and surgery.

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* See reports, pages 427-431-440.

A considerable portion of the apparatus loaned by institutions and individuals was grouped together in a "Practical Electrical Laboratory," the care of which was intrusted to Mr. Max Osterberg, of Columbia College, in whose hands it was made to give daily and nightly a series of beautiful demonstrations. Mr. Osterberg in this department organized also a course of popular electrical and X-ray lectures, a supplementary X-ray exhibit, and with the help of Tiffany and Company, an exhibit of the peculiar fluorescent nature of certain diamonds. The popularity of this section may be judged from the fact that the crush was so great several times as to break down the brass rails around the exhibits.

Professor Elihu Thomson made, by request, a personal exhibit, not only of electrical models to illustrate his inventions, but a number of devices to illustrate the principles discovered and described by him, in alternating currents, under the name of repulsion phenomena. One of the most interesting and puzzling parts of this exhibit was the incandescent lamp floating unconnected under water, but lit up by means of an adjacent coil. A brief popular lecture was given several times each evening on this exhibit by Mr. S. E. Whitaker, from Professor Thomson's laboratory.

One portion of the Historical and Loan Exhibit that was found very interesting by everybody, was the collection of about 350 models of electrical inventions, contributed by the United States Patent Office and placed in charge of an official from that department. This collection went back to the beginnings of electrical industry during the past fifty years in this country, and was particularly rich in models relating to dynamos, motors and lamps. It was supplemented by a kindred collection of models and earliest forms of apparatus, illustrative of the varied and numerous inventions of Mr. Edison, loaned by himself and several other persons. All this apparatus was placed, as far as possible, under glass, and was carefully grouped and labeled, forming a most instructive and impressive review of the growth of the electrical arts.

In one special branch, this historical display of apparatus was remarkably rich—that of incandescent lamps. Mr. W. J. Hammer, from his celebrated collection, made a most striking exhibit of hundreds of these bulbs, dating from the very earliest to the very latest. This he supplemented by a number of valuable relics and souvenirs, and by a collection of autograph portraits of leading men in electricity in this country and Europe. A board comprising pieces of famous circuits was loaned by him for use in connection with various exercises at the exposition on the opening and other nights.

It is impossible to omit mention of the exhibit made by Mr. D. McFarlan Moore of his system of lighting by vacuum tubes, in which the illumination is caused solely by setting the rarefied air into agitation by electricity. The tubes, several feet in length, usually, though in some cases as short as ordinary bulbs and often twisted into all kinds of beautiful shapes, were grouped within a small room from which all other light was carefully excluded, and then set glowing with a soft, white, moonlight effect. The crush to see these "sticks of daylight" was enormous. A special test of the economy of the system was made during the exhibition by a committee of members of the American Institute of Electrical Engineers, when the figures obtained were such as to afford great encouragement as to the future of this system of lighting. Both Mr. Edison and Mr. Tesla announced, before the exhibition closed, that their work in the same direction was hopeful; and hence it will be seen that the stimulus given to this yet undeveloped but very important field of electrical industry was among the beneficent results of the exhibition.

The co-operation of allied interests in telegraphy and telephony has already been referred to. The most striking single exemplification of this was afforded by the sending of a cable message around the world from the exhibition building on May 16, when some 10,000 people gathered to witness the exploit and hear Dr. Chauncey M. Depew deliver an oration on the progress and future of electricity. The message was written by Dr. Depew to Mr. E. D. Adams, president of the Cataract Construction Company, and was replied to by that gentleman. It was sent by President A. B. Chandler, of the Postal Telegraph-Cable Company, and received by Mr. Edison, who thus made the first public appearance of his life. The departure and return of the message and its reply were signaled to the great and enthusiastic throng by the flashing of two huge glass arrows, one over each balcony, made for the purpose by Mr. D. McF. Moore. The official reports of this telegraphic and cable feat will be found on page 422.*

After the main function, the guests of the evening were received at an electrical banquet, served in the roof garden by the Exposition Company, and prepared with the help of the electrical cooking and heating apparatus loaned from the exhibit of the New York Edison Company. To nearly all the guests, this event was a startling novelty.

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*Reports of Western Union and Postal Telegraph Companies.

A pretty feature of the exhibition was a forty-foot model of the Erie canal, operated electrically by the towage system of Mr. Richard Lamb, as tried on the canal itself. The section of the canal was seen as in actuality, with the wires suspended above it, and the "electric mule," or motor, traveling up and down with two canal boats in tow. In contrast was also shown the old method, with mules hauling from the time-honored tow path, whence even presidents have risen. The model was loaned by Mr. F. W. Hawley, to whom the exhibition was indebted for much other invaluable assistance.

The educational aspect of the exhibition was early appreciated by the public, and every day witnessed the arrival of large numbers of children from public and private schools in New York and the vicinity. During the month, the exhibition was visited also by various technical societies, and not only was the convention of the Association held there, but the annual meetings of both the American Institute of Electrical Engineers and the New York Electrical Society.

It is with deepest regret that this record of brilliant achievement is closed with mention of the sudden death by accident at his home, shortly after the exposition, of Mr. Harrison J. Smith, the president of the Exposition Company, and the superintendent of the New York Edison Company, in whose superb and comprehensive exhibit he had taken the keenest personal interest. Mr. Smith's death led to the election as president of the company, of Mr. C. O. Baker, Jr., to whose unremitted work and zeal the success of the exhibition was also in large measure due. The secretary of the association, Mr. Geo. F. Porter, served as secretary for the company, an arrangement not only appropriate, but of great convenience and benefit in the arduous work prior to the show, during its continuance and in closing up its affairs.

OFFICIAL REPORT OF TELEGRAPH AND TELEPHONE COMPANIES.

The Western Union Telegraph Company and the Postal Telegraph-Cable Company and the Commercial Cable Company to-day filed their official report of the transmission of the historic message of Dr. Chauncey M. Depew around the world from the National Electrical Exposition on May 16th. These reports, together with the original messages in the handwriting of Dr. Depew and Edward D. Adams, will be filed at the Smithsonian Institute in Washington, together with all of the telegraphic instruments used upon that occasion. The transcription of the messages by Thomas A. Edison, acting as the receiving operator, will also be placed in the Institute. The reports are as follows:

WESTERN UNION TELEGRAPH COMPANY
EASTERN DIVISION
NEW YORK, May 26th, 1896.

CHAS. A. TINKER,
Gen'l Supt.

F. W. HAWLEY, ESQ.,
Chairman Committee of Arrangements, National
Electrical Exposition, New York City.

DEAR SIR: Complying with your request, I have respectfully to submit the following report of the Western Union Telegraph Company's service in the transmission of the message of Mr. Chauncey M.

Depew to Mr. Edward D. Adams, and Mr. Adams's reply thereto, from the Electrical Exposition, on the evening of Saturday, May 16th, 1896.

Preparatory to transmission, the circuit was made up from the Exposition building to the following points, at which automatic repeaters were introduced, viz: Pittsburg, Pa.; Chicago, Ill.; Omaha, Neb.; Cheyenne, Wyo., Ogden, Utah; Reno, Nev.; San Francisco, Cal.; Los Angeles, Cal.; Flagstaff, Ariz.; Pueblo, Colo.; Kansas City, Mo.; Chicago, Ill.; . St. Louis, Mo.; Little Rock, Ark., to Galveston, Tex.; distance, 7,397 miles of wire—fourteen sets of repeaters.

At the Exposition building, the gold key used by President Cleveland in opening the World's Fair at Chicago, in 1893, was placed in circuit.

The messages (copies hereto attached) were handed to me (the operator) by messenger from Mr. Depew, at 8.38 o'clock, and instantly put upon the wire in direct communication with Galveston, where they were received by Col. L. C. Baker, superintendent, the transmission occupying six minutes, by the official timekeeper's (Mr. Abbot) record. From Galveston it was transmitted to Buenos Ayres via Mexican Telegraph Company and Central and South American Telegraph Company (including land lines across the continent of South America and over the Andes from Valparaiso to Buenos Ayres), 6,272 miles; via River Plate Telegraph Company, Buenos Ayres to Montevideo, 114 miles; via Western and Brazilian Telegraph lines, Montevideo to Pernambuco, 2 364 miles; via Brazilian Submarine cables, Pernambuco to Lisbon, 3,663 miles; via Eastern Telegraph Company, Lisbon to Penzance, 899 miles; via Western Union Telegraph Company's Atlantic cables, Penzance to Canso, 2,620 miles, and at 8.59½ the messages were received over the cable wire from Canso, N. S., 1,187 miles (repeaters at St. John, N. B., and Bangor, Me.), and copied upon a typewriter by Operator Geo. W. Dickson, and delivered to Mr. Depew. The two messages contained sixty-eight words, and were transmitted from the Exposition building, New York, over a total distance by land lines and cables of 24,516 miles, and received back at the Exposition building in twenty-one and one-half minutes.

Respectfully,
CHAS. A. TINKER.

POSTAL TELEGRAPH-CABLE COMPANY
EXECUTIVE OFFICE, 253 BROADWAY
NEW YORK, June 1st, 1896.

WILLIAM S. BAKER,
Vice President.

F. W. HAWLEY, ESQ.,
Chairman Committee of Arrangements, National Electrical Exposition,
Grand Central Palace, New York.

DEAR SIR: In compliance with your request, we submit the following report of the service performed by the Postal Telegraph-Cable Company and the Commercial Cable Company, in connection with the messages transmitted from and to the National Electrical Exposition hall in the Grand Central Palace, New York, on Saturday evening, May 16th, 1896.

The circuit was made up from New York to San Francisco by way of Buffalo, Chicago, St. Louis, Kansas City, Albuquerque and Los Angeles, a distance of 4,118 miles as the lines run.

A second circuit was made up from San Francisco to Canso, Nova Scotia, by way of Vancouver, Winnipeg and Montreal, a distance of 4,914 miles.

From Canso to London and return, the message was handled by the Commercial Cable Company; and east of London, by the Eastern Telegraph Company.

The message, signed by Dr. Chauncey M. Depew, and addressed to Mr. Edward D. Adams, and Mr. Adams's reply thereto, were handed to us at 8.34 o'clock, when they were transmitted direct to San Francisco and thence repeated by "human relay" to the Commercial Cable Company's office at Canso, whence they were repeated by "human relays" through Waterville, London, Waterville, Canso and No. 1 Broad street, New York; from which office they began to be received back at the Exposition hall at 8.38 o'clock, having been exactly four minutes in traversing 15,518 miles of land line and cables.

The exact distances, as the lines go, were as follows:

From	New York to San Francisco.	4,118	miles
"	San Francisco to Canso....	4,914	"
"	Canso to London.........	2,823	"
"	London to New York.....	3,663	"
		——	15,518

When the message reached London, a copy was handed to the Eastern Telegraph Company, which company transmitted it from

London to Porthcurno, Land's End...	250	miles
Land's End to Lisbon................	856	"
Lisbon to Gibraltar..................	336	"
Gibraltar to Malta..................	1,126	"
Malta to Alexandria......	913	"
Alexandria to Suez.................	154	"
Suez to Aden......................	1,403	"

Aden to Bombay	1,850	miles
Bombay to Madras, about	500	"
Madras to Penang	1,497	"
Penang to Singapore	398	"
Singapore to Saigon	630	"
Saigon to Hong Kong	991	"
Hong Kong to Foochow	473	"
Foochow to Shanghai	459	"
Shanghai to Nagasaki	1,241	"
Nagasaki to Tokio, about	600	"
	13,677	miles,

and back by the same route to London, whence it was forwarded via Canso and the Commercial Cable Company's office, No. 1 Broad street, to the Exposition hall, having occupied forty-seven and one-half minutes in traversing a circuit 42,872 miles in total length.

Colonel Albert B. Chandler acted as the sending operator, and Mr. Thomas A. Edison as the receiving operator, in the Exposition hall.

Yours truly,
Postal Telegraph Cable Company,
By W. H. BAKER,
Vice President.

Commercial Cable Company,
By GEO. CLAPPERTON,
Traffic Supt.

The messages transmitted were as follows:

NEW YORK, May 16th.

TO EDWARD D. ADAMS:

God created, nature treasures and science utilizes electrical power for the grandeur of nations and the peace of the world.

(Signed) CHAUNCEY M. DEPEW.

TO CHAUNCEY M. DEPEW:

Mighty Niagara, nature's serving man, through the world's electric circuit, proclaims to all peoples science triumphant and the benevolent Creator.

(Signed) EDWARD D. ADAMS.

NEW YORK, N. Y., June 13th, 1896.

EDWARD J. HALL, ESQ.,
Vice-President and General Manager.

DEAR SIR: I beg to submit the following report on the exhibition of the "Roar of Niagara" given at the Electrical Exposition at the Grand Central Palace, corner Forty-third street and Lexington avenue, New York city, from May 2d, the opening day, to May 30th, the closing day of the show.

For the transmission of the roar of Niagara Falls to New York city, there was set up at the Cave of the Winds, on the American side of the Falls, a solid-back transmitter, incased in a wooden box, through which there protruded a horn four feet long and eighteen inches at the mount, which was screwed into the transmitter. The circuit was energized by three cells of standard Fuller battery.

The circuit between the Cave of the Winds and the Exposition building in New York was made up as follows:

From the transmitter in the Cave of the Winds through 700 feet of two-conductor emergency cable, thence through 1,000 feet of twisted pair Okonite wire, then along a metallic circuit of No. 14 iron wire, 1,500 feet long, to the Niagara Falls Exchange of the Bell Telephone Company of Buffalo.

From the Niagara Falls Exchange over the trunk wires of the Bell company to their central office in Buffalo, a distance of twenty-two miles, three miles of which consists of underground cable. From the Bell Company's office to the test station of the American Telephone and Telegraph Company in Buffalo, a distance of 3.5 miles.

From this point the circuit was over the standard No. 8 B. W. G. copper metallic circuit route of the American Telephone and Telegraph Company to 18 Cortlandt street, New York city. This distance is 474.57 miles, 3.12 of which is in underground cable.

From 18 Cortlandt street the circuit passed through the underground system of the Metropolitan Telephone and Telegraph Company to their Thirty-eighth street exchange, a distance of 3.74 miles. From this point, by means of one mile of underground and aerial cable to the switchboard in the exhibit of the Metropolitan Telephone and Telegraph Company at the Exposition building.

From this switchboard, by means of a twisted pair of wires, the circuit was led to a set of twenty police receivers placed in the centre of the exhibition hall.

The total length of this circuit is 501.92 miles, of which 11.47 is in aerial or underground cable.

The receiving telephones were connected four in series, each group being connected in multiple with the others. These instruments were placed near a working model of Niagara Falls, about twelve feet long by four wide.

Service was given from 8 p. m. until 10.30 p. m., daily except Sundays, during the intervals when the exposition band was not playing. Later, during the last ten days of the fair, owing to the urgent demand for an earlier exhibition of the roar of Niagara Falls, the service was given from 5 p. m. to 10.30 p. m.

There were about 150,000 visitors to the exposition, and it is estimated that not less than 100,000 listened to the roar of Niagara. From the date of the opening to the closing, fully 200 people were in line before the hour of connecting the circuit, the line being kept to about that number throughout the evening, and generally, when the connection was taken down, there were as many disappointed at not being able to listen. Frequent requests were made for the service outside of the regular exhibition hours, and in many cases, parties visiting the exposition in the afternoon demanded the return of the cost of admission by reason of their not being able to hear the roar.

Service was frequently given outside of the exhibition hours during the afternoon and evening, and in some cases noted people were, by the courtesy of the representatives of the Metropolitan Telephone and Telegraph Company, allowed to listen from a booth in the exhibition pay station, among whom may be mentioned: Four Judges of the Supreme Court, Chauncey M. Depew, John Jacob Astor, the Russian Consul-General and Police Commissioner Andrews and Mrs. Andrews. In addition to the above named parties, the following were entertained: Professor Bell, Thomas A. Edison, Sir Henry Irving, Seth Low, president, and several professors of Columbia College, members of the Corean Embassy, a Spanish princess (a daughter of Don Carlos), a commander in the Spanish Navy (who returned the following evening with a number of his fellow officers), and, by special invitation, on the last night of the exposition, De Wolf Hopper and his El Capitan company, consisting of about seventy-five members; the Lady Slavey company, of the Casino, also attended in a body. The colleges and schools were well represented by delegations, among them the following: Packer Institute of Brooklyn, Newark High School and several public schools in New York city and Brooklyn.

The officials of the Exposition Company informed me that the roar of Niagara was one of the most attractive features of the exposition, and was given generally without a hitch. On one occasion, I understand, the service was interrupted for about half an hour, owing to some battery trouble; and on one or two occasions there was some slight local trouble which was quickly and easily remedied. A daily test of the receivers was made, and on an average, three or four instruments were found defective, chiefly owing to broken cords, resulting from their being carelessly handled by the public.

Our exhibition was very satisfactory in every way, there being no complaints of disappointment so far as I could learn; and the remarks by those who had listened were very gratifying.

About 3 p. m. on May 9th, Professor Bell listened to the roar, using receivers Nos. 48 and 154, which were immediately set aside by the officials of the Exposition Company and placed in the glass case inclosing the model of Niagara Falls. These receivers have been turned over to Mr. Pickernell.

A photograph of Professor Bell was taken at the time he was listening to the roar of Niagara at the model of Niagara Falls and River, a copy of which please find herewith. I also hand you herewith a picture of the apparatus used at the Falls, taken from the *Buffalo Express* of Sunday, May 10th, 1896, and an illustration from the *Electrical Review* of May 13th, showing the location of the Niagara Falls model.

Very respectfully,

(Signed) C. R. TRUEX,
Special Agent.

TRANSMISSION OF POWER FROM NIAGARA TO NEW YORK.

PITTSBURG, PA., September 25th, 1896.

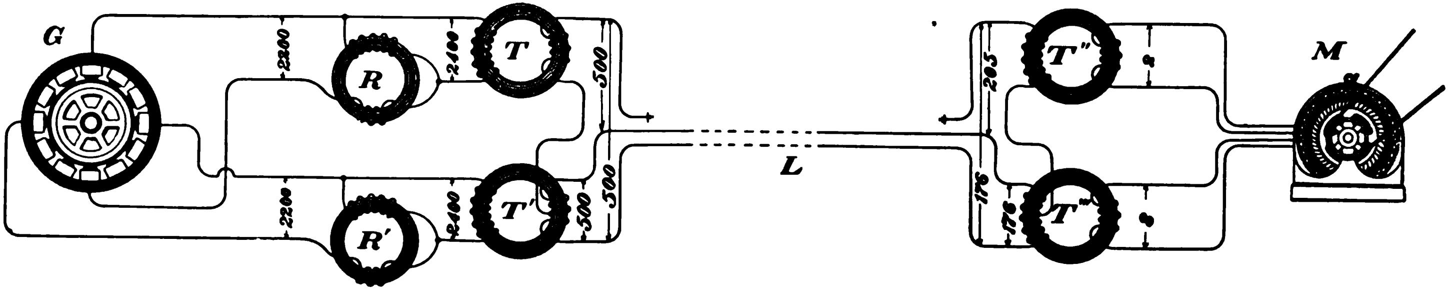
T. COMMERFORD MARTIN, ESQ.,
No. 203 Broadway, New York City, N. Y.

DEAR SIR: In compliance with your request of September 19th, I am glad to furnish information concerning our part in the transmission of power from Niagara Falls to New York city in connection with the Electrical Exposition last May.

I inclose herewith the following papers:

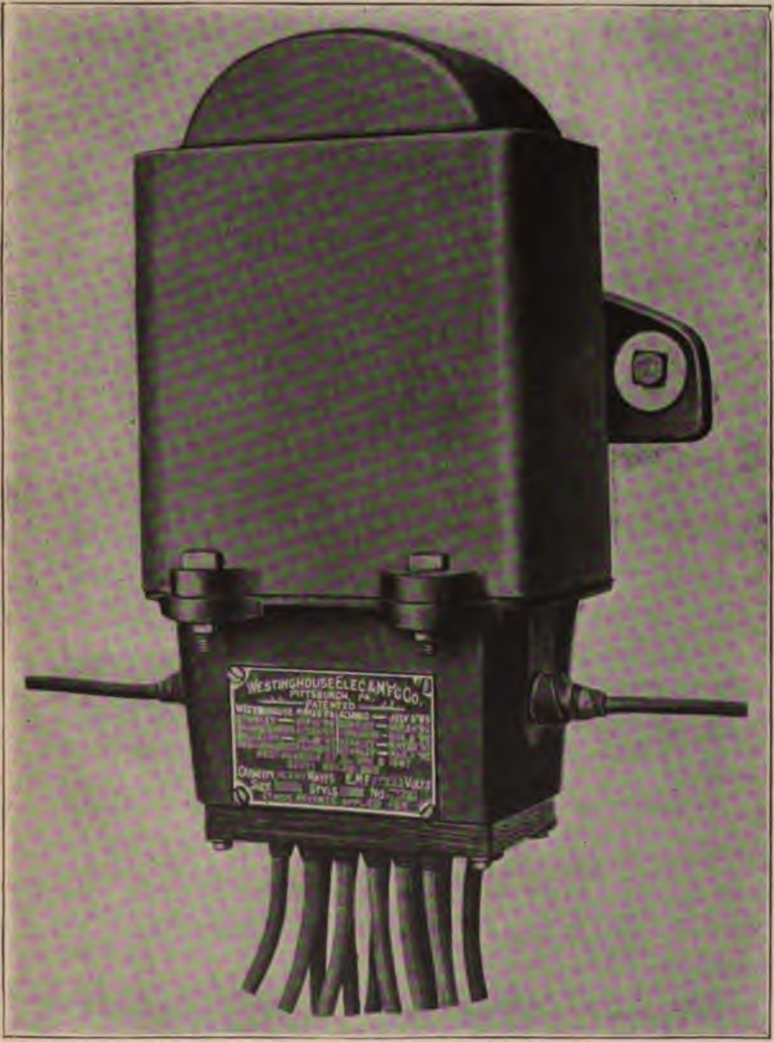
First. Diagram showing connections of circuit from generator, regulating transformers and two-phase, three-phase transformers at Niagara; the line; and the three-phase, two-phase transformers and the motor in the Exposition building, New York city.

Second. Copies of specifications for the two-phase, three-phase transformers used at Niagara and the transformers used in New York.



TRANSMISSION OF POWER FROM NIAGARA FALLS TO THE ELECTRICAL EXPOSITION, NEW YORK, MAY, 1896.

Third. Copy of electrical specifications for the motor.

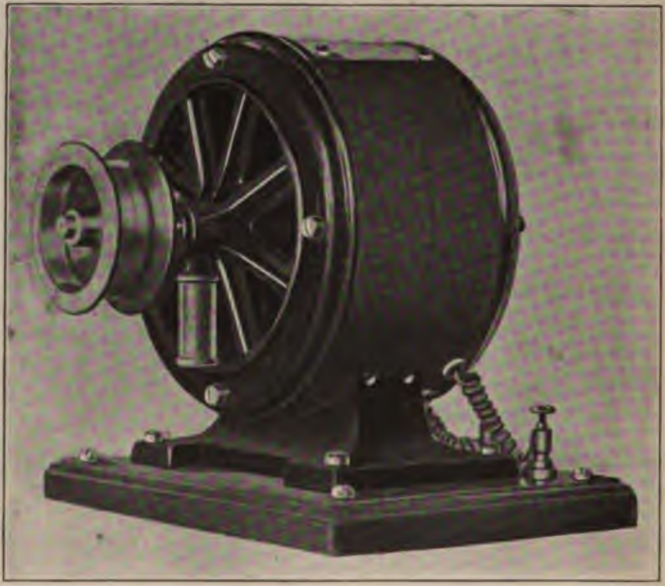


Fourth. Photograph of one of the two-phase, three-phase transformers used at Niagara.

Fifth. Photograph of the motor.

Sixth. Copy of my notes on experiments made at Niagara up to the successful accomplishment of the transmission.

From May 8th, to the closing of the Exposition, the model of the plant of the Niagara Falls Power Company at the Exposition building, Lexington avenue and Forty-third street, New York, was driven by a two-phase, alternating-current motor, constructed by the Westinghouse Electric and Manufacturing Company.



The period of operation was from eight o'clock to ten o'clock in the evening. On the evening of May 28th, after the cyclone at St. Louis, the Western Union Telegraph Company had so much business that they could not spare the line, and for this reason the motor was not operated. The service was also interrupted the latter part of one other evening during the month, by a severe thunder storm near Buffalo.

The energy was. transmitted by three-phase, alternating currents; two of the conductors of the three-wire circuit were telegraph wires furnished by the Western Union Telegraph Company; the third was the earth, through ground connections in the power house at Niagara and in the Exposition building, New York city. The wires used are described in Mr. Brown's letter addressed to you under date of September 18th. The electrical connections are indicated in the accompanying diagram.

At Niagara, two-phase current at a frequency of twenty-five cycles per second and a potential approximating 2,200 volts was obtained from one of the 5,000-horse power generators of the Niagara Falls Power Company.

Two small transformers, connected in the manner devised by Mr. Chas. F. Scott, and first described by him in his paper read before the annual convention of the National Electric Light Association, in Washington, D. C., March 1st, 1894, received the two-phase current and delivered to the transmitting circuits three-phase current. The potential delivered by these transformers, when supplied with current at 2,200 volts, namely, 450 volts, was found to be rather low for good results, and the potential delivered to the line at Niagara was therefore increased to 500 volts by the use of two small transformers, connected as Stillwell regulators, in each side of the two-phase primary circuit.

The transformers at the New York end of the line were of the dimensions of the standard three-kilowatt Westinghouse transformer, but, as shown in the attached specification sheet, they were designed to deliver only fourteen watts each, and the energy required to magnetize the iron core was less than one and one-half watts. The energy lost in the copper, when the transformer was delivering fourteen watts, amounted to only one-quarter of one watt.

By actual test, the energy required to drive the motor was eight watts. The clearance between armature and field was one-fiftieth of an inch. No very accurate measurement of the power developed was taken, but when the line was in favorable condition, that is, when the weather was dry and the leakage consequently low, the power developed was probably about one-thirtieth of one horse power. The motor was of the induction type and wound for two-phase currents.

The electrical specifications for this motor were made out by Mr. B. G. Lamme.

The specifications for the transformers were made out by Mr. J. B. Whitehead, under the immediate supervision of Mr. Chas. F. Scott, the electrician of the Westinghouse Company.

Referring to the diagram, G is the 5,000-horse power, two-phase generator; R and R′ the regulating transformers; T and T′ the two-phase, three-phase transformers at Niagara; L the line or transmitting circuit; T″ and T‴ the three-phase, two-phase transformers in New York, and M the motor.

The potentials given in the diagram are closely approximate for the Niagara end of the line; for the New York end of the line they roughly represent what may be called the average conditions of operation.

The potential of the currents delivered at the New York end of the line varied between rather wide limits, from one night to another, depending apparently to a very considerable extent upon the leakage from the line, as influenced by atmospheric conditions.

The copy of my notes made at Niagara will probably give you a sufficient account of the initial failure to operate the alternating-current motor, May 2d and May 3d, the successful operation of the direct-current motor, May 4th, and the successful operation of the alternating-current motor, May 7th.

Very truly yours,

(Signed) L. B. STILLWELL,

Electrical Engineer and Assistant Manager.

TRANSMISSION OF POWER FROM NIAGARA TO NEW YORK.

Saturday, May 2d, 1896. Tests began at 8. p. m. An attempt was made to transmit three-phase current over two telegraph wires, with earth connection for one conductor. Potential at Niagara, 350 volts; potential at New York reported higher on one phase than on the other two phases; not sufficient to run motor. Two-phase connections were then tried with 350 volts on each phase; earth return, common; potential on one phase higher than on the other; not sufficient to run motor. Difficulty experienced in securing closed circuits, as one of the circuits was found opened at Niagara, and later, probably, in New York.

Sunday, May 3d, 1896. Two-phase current from generator No. 2 at potential approximating 2,200 volts, was transformed to three-phase current at potential approximating 350 volts. This was accomplished by means of two special transformers having the Scott two-phase, three-phase connections.

Tests began about 8 p. m. Using three-phase currents with 450 volts on each phase at Niagara, the potentials at Exposition building, New York, as measured by 3,500-ohm voltmeter, were, respectively, 160, 125, 125 volts. When connected to motor, potentials dropped and motor did not revolve.

Connections of transformers were changed, and two-phase currents of 350 volts were delivered to the two wires of the telegraph circuit, the earth being used as a common return, and shortly before 10 p. m. current on both circuits was reported delivered to the Exposition building, Forty-third street and Lexington avenue, New York city.

(The circuits consisted of No. 11 Birmingham gauge copper wire from Buffalo to New York, and No. 4 iron wire from Niagara to Buffalo.)

The potential at New York end of line on one phase was 160 volts, as measured by a voltmeter having a resistance of 3,500 ohms.

This would indicate a current of .046 ampere. The potential on the other phase in New York was 130 volts, as measured by the same voltmeter. This would indicate a current of .037 ampere.

The apparent energy delivered by one circuit was, therefore, 7.36 watts, and by the other circuit, 4.81 watts. When the transformers and special two-phase motor at New York end of line were connected to the circuits, the potential dropped very low and the motor could not be operated.

Direct current at 575 volts (approximate) was then tried, one terminal being connected to one of the circuits, the other to earth; potential at New York too low to run small direct-current motor. The other wire was then connected in parallel with the first; motor reported to be running very nicely;

potential delivered equals 160 volts. The two wires used were then successively disconnected at the New York end of the line; the results showing that the resistance of one circuit was very much higher than that of the other.

Monday, May 4th, 1896. Tests were begun shortly after 7 p. m. Two-phase alternating current, with earth return common to both circuits, was first used; potential on each phase at Niagara, 650 volts. Fuse strips on switchboard at Buffalo melted and circuit was opened. These were replaced and it was then reported that the circuit was opened somewhere between Buffalo and New York. Two other wires were substituted for those first used, and direct current at 575 volts was transmitted over these two wires connected in parallel, the return circuit being established through the earth. The motor was satisfactorily operated.

Tuesday, May 5th, 1896. Direct-current motor operated as on May 4th.

Wednesday, May 6th, 1896. Direct-current motor operated as on May 4th.

Thursday, May 7th, 1896. Three-phase alternating current connected to circuits consisting of two telegraph wires and earth about 7 p. m. Primary potential at generator about 2,200 volts on one phase and about 2,300 volts on the other phase; no voltmeter available to measure potentials delivered to circuit, but using lamps it was judged that potential to each circuit was very nearly 500 volts.

Mr. MacClaren reported from New York city that alternating-current motor was operated satisfactorily, potentials at that end of the line increasing when the motor was connected to the circuits.

This effect was probably due to capacity of the circuits being counteracted by inductance when the motor and step-down transformers are connected; the current then more nearly coinciding in phase with the impressed electromotive force.

NEW YORK, September 18th, 1896.

T. C. MARTIN, ESQ.,

Chairman Historical and Loan Exhibit Committee.

DEAR SIR: The two wires furnished by the Western Union Telegraph Company for transmission of power from Niagara Falls during the electrical exhibition are described as follows:

	Miles.		Weight Per Mile.
From Niagara Power House	1½,	copper,	210 lbs.
to Buffalo.............	26½,	iron,	730 lbs.
From Buffalo to Jersey City,	419,	copper,	210 lbs.
From Jersey City to exhibition building..........	6,	copper,	67 lbs.
	453		

(6 miles, Jersey City to exhibition building, underground.)

The two wires are alike in all respects and on the same line of poles. They have a line resistance of about 21.25 ohms each. The route is via Delaware, Lackawanna and Western Railroad between Buffalo and Jersey City.

Very truly yours,

(Signed) A. S. BROWN, Electrical Engineer.

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American Carbon Company, Noblesville, Ind.
American Circular Loom Company, Boston, Mass.
American Electric Heating Corporation, Boston Mass.
American Stoker Company, Dayton, Ohio
American Watchman's Time Detector Company, New York
Anchor Electric Company, Boston, Mass.
Ashcroft Manufacturing Company, New York
Ashton Valve Company, Boston, Mass.
Babcock and Wilcox Company, New York
Ball-Bearing Company, The, Boston, Mass
Ball Electric Light Company, New York
Ball and Wood Company, New York
Beardsley, L. S., New York
Bernstein Electric Company, Boston, Mass.
Birdsall Electric Manufacturing Company, New York
Bishop Gutta Percha Company, New York
Bonta Manufacturing Company, Hoboken, N. J.
Borne, Scrymser Company, New York
Bossert, William F., Utica, N. Y.
Boynton, Multivolt Battery Company, New York
Bradford Belting Co., Cincinnati
Brady, T. H., New Britain, Conn.
Bridgeport Car Equipment Company, Bridgeport, Conn.
Brill Company, J. G., Philadelphia, Pa.
Brush Electric Company, Cleveland, Ohio
Bryan–Marsh Company, New York
Burhorn and Granger, New York
Burry, John, New York
Buyers' Reference Company, New York
Calculagraph Company, The, New York
Card Electric Motor and Dynamo Company, Cincinnati, Ohio

Carpenter Enamel Rheostat Company, Hoboken, N. J.
Chapin–Douglas Electric Company, New York
Clonbrock Steam Boiler Company, Brooklyn, N. Y.
Columbia Incandescent Lamp Company, St. Louis, Mo.
Columbia Rubber Works Company, New York
Cook's Sons, Adam, N. Y.
Consolidated Safety Valve Company,. New York
Corey, R. B., New York
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Cutter Electrical and Manufacturing Company, Philadelphia, Pa.
Dale, Farrell and Company, New York
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Diamond Electric Company, Peoria, Ill.
Diehl Manufacturing Company, Elizabethport, N. J.
Dixon Crucible Company, The Joseph, Jersey City, N. J.
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Edison Electric Illuminating Company, New York
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Electrical Age, New York
Electric Arc Lamp Company, New York
Electrical Engineer, New York
Electricity Newspaper Company, New York
Electric Power, New York
Electrical Review, New York
Electric Storage Battery Company, Philadelphia, Pa.
Electrozone Company, The, New York
Empire Self-Lighting Oil Lamp Company, New York
Excelsior Electric Company, New York
Fayerweather and Ladew, New York
Ferracute Machine Company, Bridgeton, N. J.
Fiberite Company, The, Mechanicsville, N. Y.
Forest City Electric Company, Cleveland, Ohio
Fort Wayne Electric Corporation, Fort Wayne
Fuel Economizer Company, Matteawan, N. Y.
Gamewell Fire-Alarm Telegraph Company, The, New York
General Electric Company, The, Schenectady, N. Y.
General Incandescent Arc Light Company, New York

Gold Car Heating Company, New York
Goldstein, W., New York
Gordon-Burnham Battery Company, New York
Goubert Manufacturing Company, The, New York
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Sprague Electric Elevator Company, New York
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Standard Thermometer Company, New York
Standard Underground Cable Company, Pittsburg, Pa.
Stanley Electric Manufacturing Company, Pittsfield, Mass.
Stanley and Patterson, New York
Stirling Company, The, Chicago, Ill.
Straight Line Engine Company, Syracuse, N. Y.
Taunton Locomotive Manufacturing Company, Taunton, Mass.
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